THE EVOLUTION AND ART SIGNIFICANCE OF PYROTECHNICS

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CHAPTER I

STATEMENT OF THE PROBLEM, DEFINITION OF TERMS, AND ORGANIZATION OF THE THESIS

> There was one bursting now, a delicate constellation of many coloured stars which drifted down and lingered in the still air. Watching it she thought that of all the arts this was the one which showed the greatest contrast between the raw materials and the finished work. Words, pigments, notes and music--all of these unmarshalled, possessed a certain beauty of their own. . . . But this fiery architecture, these fragments of luminous music, these bright, dreamlike, and impermanent pictures in the sky--what had they to do with nitre, sulphur and charcoal, with gummed paper, cotton wick, and a handful of mineral salts.[1]

Pyrotechny is a dramatic form of visual art, the simple beauty and magnificence of which can be understood alike by old and young of all classes. It requires no cultural background or knowledge of technical skill to be appreciated quite fully. The displays satisfy the modern desires to be entertained in large groups without personal effort. The abstract designs are spectacular and as gratifying as a good moving picture or an art gallery. The representations provide both comedy and continuity. A subjective emotional response is the result.

To be sure, some of the enjoyable qualities would occur merely in the combustion of the indispensable materials, but when the chemist and the artist work together, the construction of awe inspiring displays of beauty is possible. All the requirements of a work of art can be present.

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[1] Jan Struthers, Mrs. Miniver (New York: Harcourt, Brace and Company, 1940), pp. 22-23.

I. THE PROBLEM

Statement of the problem. It was the purpose of this study (1) to trace the evolution of pyrotechny from its antecedents to the current uses, considering both the substances making fireworks possible and the activities out of which they developed, as well as the development of pyrotechnic form proper; (2) to evaluate the emotional factors evidenced in pyrotechnic forerunners and in actual displays from the standpoint of aesthetics; and (3) to show evidence that fireworks are a form of art and have been partially accepted as such.

Limitations of the problem. An analysis of the art qualities present in a field of work,which can leave no actual records of itself, presents a peculiar problem. Ordinarily it is possible to gather the actual items under discussion, reproductions of them, or at least scaled and accurate drawings of their remaining fragments for investigation and comparison. Units of design can be isolated and studied. The frequency of occurrence can be determined, and the evolution of specific units can be traced and catalogued.

Pyrotechnics simply cannot accommodate such an analytical approach.

Nothing remains at the end of a fireworks show which can be passed on to posterity except verbal reminiscences, written descriptions, and occasional pictographic records. Today color photography makes possible records which are more reliable than ever before.

Verbal records of early periods are unreliable because the observers were usually so awe-struck that their powers of accurate description were numbed. Psychologists have demonstrated that the inability to describe what has been seen when excited is a common occurrence, and our forbears were no exception. Reading Horace Walpole's description of the fireworks display shown at the Peace of Aix-la-Chapelle,[2] it would hardly seem possible that Hodgkin's references were of the same event.[3] Since this exhibit was in the eighteenth century after pyrotechny had lost most of its mystical aura, and no longer exerted any particular religious influence, it is easy to see that earlier records would be at least as unreliable and exaggerated as Walpole's and Streatfield's descriptions.

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[2] R. A. Streatfield, Handel (New York: John Lane and Company, 1909), pp. 200-1.

[3] John Eliot Hodgkin, "Halinitropyrobolia" in Rariora (London: Sampson, Low, Marston and Company, Ltd., 1902), III, 70-72.

No pictographic record is as liable to emotional inaccuracies as verbal description. Many of the early pyrotechnic prints, however, merely depicted by daylight the elaborate structures to be used. Sometimes a list of the fireworks was added below the picture. A few represented the display in progress but they usually showed everything going off at once which does not give the impression received at the actual performance.[4]

As a result of these uncontrollable conditions the writer has tried, in the first place, to show the existence of the more basic art qualities in pyrotechnic exhibits. Such factors as color, pattern, and abstraction and representation were considered. Secondly, the writer has discussed the relationship of emotion to art and has endeavored to demonstrate an analogy in the emotional responses to pyrotechnical displays.

To a certain extent there was a limitation imposed by the lack of primary material. However, it was possible to get almost all of the books mentioned in pyrotechnical bibliographies. One of the most frequently mentioned of the earlier books is Rugierri's Precis Historique sur les Fetes, les Rejouissances Publiques (1739). No record of any complete translation into English could be found and the writer was not able to use the one German translation available. Some of the other primary sources are not in the United States, but were quite adequately referred to and abundantly quoted in secondary materials.

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[4] A. St. H. Brock, Pyrotechnics: The History and Art of Firework Making (London: Daniel O'Connor, 1922), p. 23.

A peculiar lack of information seems to exist in regard to contemporary displays. Otto K. Olson, who provided the electric illumination at the opening of the San Francisco Bay Bridges believed that the Pacific Gas and Electric Company of San Francisco might be able to provide information about the (not new) fireworks used at that time. They could not. Neither the Chamber of Commerce, the Mayor's office, nor the San Francisco Public Library could give any information or suggest any other possible sources. A similar situation was found concerning the fireworks shown at the San Francisco Exposition and the New York World's Fairs of 1939-40.

A final limitation not anticipated at the time this paper was begun was the ban put upon the manufacture of fireworks subsequent to the outbreak of the war, December 7, 1941. The fireworks men have pretty well dispersed and it was difficult to get in touch with any of the contemporary designers.

II. DEFINITIONS OF TERMS USED

Pyrotechnics (fireworks). These words have been used synonymously and shall be interpreted to mean primarily the products of an art for producing scenic effects by means of fire. In general the source of the fire is gunpowder or another mixture of sulphur, nitre, and carbon. Occasionally bonfires and gas jets are used. With few exceptions the artifices are propellant or explosive in nature or a combination of both.

Aesthetics. Aesthetics here shall be considered to mean the principles of beauty, a synthesis of the products of intellectual and emotional stimulation by things which give pleasure in the visual field. This includes feelings of pleasure due to associations with things, people, and ideas gone before, and impressions which seem inexpressible and are based on the pleasure and satisfaction derived directly from looking at the material.[5]

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[5] Charles Mauron, Aesthetics and Psychology (London: Hogarth Press, 1935), p. 55. "Expressive art then, is, first and foremost, art which, through the medium of sound or colour, transmits what we call 'states of mind' . . . a sensation in our nervous system cannot remain isolated; it links up with past impressions; it awakens feelings; it excites desires." See also George Santayana, The Sense of Beauty (New York: Charles Scribners and Sons, 1896), p. 267. "Beauty as we feel it is something indescribable--what it is or what it means can never be said . . . it is an affection of the soul, a consciousness of joy and security, a pang, a dream, a pure pleasure."

III. ORGANIZATION OF THE REMAINDER OF THE THESIS

The review of literature is divided into four sections. The first is made up of selected material from the several phases of science and customs which the writer felt were forerunners or roots of pyrotechnics. The second group includes most of the available material on the history of fireworks. The next division of literature is of contemporary writings on the current uses of pyrotechny, both functional and recreational, with the emphasis on the latter. The last section contains a considerable sampling of material on aesthetics and psychology from which the writer drew material for analyzing the art significance of *feu-de joie*. Included among these are a number of books on the ballet, as unpreservable a form of art production as celebrational fireworks.

The evolution of pyrotechnics reviewed in Chapter Three is divided into two parts. The first tells of the activities which probably were responsible for the birth and development of fireworks. Magic and early religions used artifices to facilitate charms and to excite religious fervor and devotion. Advances in alchemy assisted in the advent of the scientific era. Mystery no longer endowed fireworks with supernatural qualities. Chemistry and modern warfare then stepped in to provide the necessary knowledge and development of technique to bring about the creation of recreational displays and functional fireworks as we know them today. The second part describes a possible path of the discovery of materials necessary for the construction of artifices and the advance of pyrotechny. The discovery of combustion and the identification and isolation of specific slow burning material brought about the creation of fireworks. The invention of gunpowder gave impetus to renewed activity in the devising of such artifices, and perfection of color effects was the final major contribution from the standpoint of materials.

Chapter Four formulates a set of criteria for aesthetic values. All these can be found in a consideration of primitive art. Nature provides all the requisites for a work of art and also sets up the standards for evaluation, so that the direct source of primitive art was nature. An interestingly parallel development of fireworks can be traced in which pyrotechnics evolved simultaneously with other primitive arts from much the same set of stimuli. After discussing the various qualities peculiar to pyrotechny, the possible aesthetics of fireworks are considered. The formal principles of art and elements of design evident in fireworks shows are pointed out. The use and associational values are identified. Further evidence is then provided to show that pyrotechny can be an art form even though it is not always so.

Lastly, there is a summary and conclusion followed by a bibliography, an appendix of letters from exposition managers and fireworks men, and a group of plates.

CHAPTER II

REVIEW OF LITERATURE

Four brief pages in a book of fiction probably have had a more intimate bearing on this paper than the total of the rest of the references. The thoughts of Mrs. Miniver at a Guy Fawkes fireworks celebration[1] first started the writer on the present investigation and they still seem convincing proof of the solidarity of the contention that fireworks are a work of art.

I. LITERATURE ON PYROTECHNIC ANTECEDENTS

Introductory comments in the literature of the history of pyrotechnics led the writer in several directions searching for the activities and materials out of which pyrotechnics presumably developed. Faber's[2] work suggests a path through magic, fireworship, and alchemy. Brock[3] indicates a leaning toward the same general sequence with an emphasis on the early social significance of fire to mankind.

The obvious beginning was fire. Of considerable value were Frazer's Golden Bough[4] and Myths of the Origin of Fire.[5] Although much of this material was in no way related to pyrotechnics, parts throughout showed the influence of fire in celebrations and worship. Dexter[6] traces many of Brittain's Christian festivals and holidays back to fire-worship. Some of these events, even today, are commemorated with pin wheels, Roman candles, and rockets.[7] Hough[8] discusses pyromancy, the belief in the magic powers and properties of fire, and other phases of the social significance of fire, many of which were psychological as well. In his publication, Fire as an Agent in Human Culture, Hough[9] also discusses briefly the ancient gods connected with fire. Materials by Blavatsky[10] and McGovern[11] were used for references on Zoroastrianism. Olliver presents a wealth of material on the symbolic practices of magic and alchemy in his book An Analysis of Magic and Witchcraft.[12]

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[1] Jan Struthers, Mrs. Miniver (New York: Harcourt, Brace and Company, 1940), 288 pp.

[2] Henry B. Faber, Military Pyrotechnics (Washington: Government Printing Office, 1919), 3 vols.

[3] A. St. H. Brock, Pyrotechnics: The History and Art of Fireworks Making (London: Daniel O'Connor, 1922), 180 pp.

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[4] Sir James George Frazer, The Golden Bough (New York: The Macmillan Company, 1935), 12 vols.

[5] Sir James George Frazer, Myths of the Origin of Fire (New York: Macmillan and Company, 1930), 266 pp.

[6] T. F. G. Dexter, Fire Worship in Brittain (London: Watts and Company, 1939), 47 pp.

[7] Guy Fawkes' Day is one example.

[8] Walter Hough, Fire as an Agent in Human Culture (Washington: Government Printing Office, 1926), p. 182.

[9] Ibid., 270 pp.

[10] H. P. Blavatsky, Alchemy and the Secret Doctrine (Wheaton, Illinois: Theosophical Press, 1927), 204 pp.

[11] William Montgomery McGovern, The Early Empires of Central Asia (Chapel Hill: University of North Carolina Press, 1939), 579 pp.

Of the influence of fire and fireworks in magic there are but a few references. Transcendental Magic, Its Doctrine and Ritual[13] by Levi and Redgrove's Bygone Beliefs[14] are valuable sources. Throndike[15] has made a tremendous collection of material, providing translations of quantities of manuscripts, secret documents, letters, and the like. Some of these concern "flying fire," marvelous lights, and combustibles. Alchemy takes a place very close to magic, for much of the work done by the magicians was used as a cover up for their alchemical activities which, Redgrove points out, were "the outstanding product of mysticism and scholasticism . . . ."[16] Whether they were alchemists or just magicians they worked with the same materials. Hime[17] reproduces a letter showing the way Friar Bacon explained in cryptic chapters in a manuscript how saltpetre might be refined, confusing his chance readers with a discussion of the philosopher's stone, the object of the never ending search of the alchemists. Some of the very earliest references to alchemy are presented by Martin in _The Lore of Cathay_.[18] Introductory chapters to a history of the origin of artillery by Hime[19] provide material on gunpowder and its antecedents. Brook[20] and Faber[21] again offer abundant sources.

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[12] C. W. Olliver, An Analysis of Magic and Witchcraft (London: Rider and Company, 1928), 244 pp.

[13] Eliphas Levi (translated by A. E. Waite), Transcendental Magic, Its Doctrine and Ritual (n.p., n.n., 1896), 192 pp.

[14] H. Stanley Redgrove, Bygone Beliefs (London: William Rider and Sons, Ltd., 1920), 205 pp.

[15] Lynn Throndike, A History of Magic and Experimental Science (New York: The Macmillan Company, 1923), 2 vols.

[16] Redgrove, op. cit., p. 5.

[17] Lieutenant-Colonel Henry W. L. Hime, The Origin of Artillery (New York: Longmans, Green and Company, 1915), pp. 105-6.

II. LITERATURE ON THE HISTORY OF PYROTECHNICS

Probably the outstanding reference on the evolution of fireworks is that written by Brock.[22] He is a contemporary from a family which has been in the fireworks business for generations and it is his work which is used in the fourteenth edition of the _Encyclopedia Britannica_.[23] His book contains an excellent bibliography. A bibliography is also included at the end of the article on pyrotechnics in the 1930 edition of The New International Encyclopedia.[24] The writer was fortunate enough to find in the San Francisco Library a set of volumes called Rariora.[25] Volume III contains a book called "Halinitropyrobolia," a now obsolete synonym for pyrotechnics. Rariora is a sort of catalogue of materials collected by Hodgkin. He gives comments about, or translations from, each of the books about fireworks which he has, as well as offering remarks about the authors.[26]

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[18] W. A. P. Martin, _The Lore of Cathay_ (New York: Fleming H. Revell Company, 1901), 480 pp.

[19] Hime, _op. cit._, 231 pp.

[20] Brock, _op. cit._, 180 pp.

[21] Faber, _op. cit._, Vol. I.

[22] Brock, _op. cit._, 180 pp.

[23] A. St. H. Brock, "Fireworks," _The Encyclopedia Britannica_, 14th edition, IX, 281-83.

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[24] "Pyrotechnics," The New International Encyclopedia (New York: Dodd, Mead and Company, 1930), XIX, 405-6.

[25] John Eliot Hodgkin, Rariora (London: Sampson Low Marston and Company, Ltd., 1902), 3 vols.

[26] Many of the books in Brock's bibliography were printed in French, German, or Italian. These the writer was not able to use. The writer felt that the present bibliography would be of greater value if some of these books were included. By choosing books which appeared in Brock's bibliography, or books which were quoted or referred to in numerous other works, the following annotated bibliographical entries were assembled out of Rariora.

Biringuccio, Vanoccio, De la Pirotechnia. Venetia: Venturino Rossinello, 1540. This was at one time a standard book on the subject, probably the most complete and trustworthy source of information on matters of metalurgy at the time of publication. Chapter X is entitled "Manner of Appropriating Artificial Fire to Fetes and Triumphal Displays."

Norton, Robert, The Gunner, Shewing the Whole Practise of Artillery. London: A. M. for Humphry Robinson, 1688. This contains seventy-four chapters on Ordnance, its construction and use, and all things needful in Gunnery.

It would seem to contain all the information available to the world at that time.

Malthus, Thomas, *A Treatise of Artificial Fire-Works Both for Wars and Recreation: With Divers Pleasant Geometric Observations, Fortifications, and Arithmetical Examples*. 1629. This printed title was preceded by the following engraved title: "A Treatise of Artificial Fireworks." It includes instructions for making rockets, Serpents, Golden Rayne, Starres giving great reports, Saucissons, Fierie Boxes, Fierie Lances, Girondelles or Fierie Wheels, Ballouns, and Flying Saucissons. This gives a very accurate idea of the development of the art at that period.

Lorrain, Hanzelet, *La Pyrotechnie*. I and Gaspard Bernard, 1630. This concerns military practises primarily but shows an illustration of what must be the earliest representation of crackers, called in English books "fisgigs."

Bate, John, *The Mysteries of Nature and Art*. London: Thomas Harper, 1635. " . . . withall (teaching) most exactly all manner of fire-works for Tryumph and Recreation."

Babington, *Pyrotechnia, or a Discourse of Artificial Fire-works*. London: 1635. It is outstanding for its descriptions of elaborate or complex devices which the age delighted in such as "The manner of composing a wheele, which having finished his revolution, shall represent a Coat of Armes," and "How to make a Siren or Mermaid, playing on the water."

Frezier, M., *Traite Des Feux D'Artifice pour le Spectacle*. Paris: 1747. A good practical treatise and a short historical review of some of the most celebrated fetes.

Rugierre, Claude, *Precis Historique sur les Fetes, les Spectacles et les Rejouissances Publiques*. Paris: 1830. An indispensable work containing a mass of historical and gossiping information.

The writer would also like to include a few titles of frequently mentioned books which were not included in Hodgkin's collection.

D'Orval, *Traite des Feux d'Artifice pour le Spectacle et pour le Guerre*. Bern: 1750.

He owns an extensive collection of pictures. These have been reproduced and arranged chronologically to show graphically the history of fireworks displays. One of the earliest books written in the United States on the subject of fireworks was done by Cutbrush.[27] He died before its completion, but his wife published in in 1825.

During the last war military pyrotechnics were of considerable importance. The United States government had given a commission to Henry B. Faber to write a paper on the subject, but, since the war ended before he had completed his writing, his commission was extended and he developed the first part of his paper on the history of pyrotechnics more completely.[28] It was from this material that the writer was first encouraged to pursue the present topic.

Chertier, F. M., Nouvelles Recherches sur le Feux d'Artifice. Second edition. Paris: 1854.

Tessier, Paul, Chimie Pyrotechnique. Paris: 1859.

Browne, W. H., The Art of Pyrotechny. London: 1879.

Sonzogno, Cezare, Il Pirotecnico Moderno. Milan: 1892.

[27] James Cutbrush, A System of Pyrotechny (Philadelphia: Clara F. Cutbrush, 1825), 528 pp.

[28] Faber, op. cit., Vol. I.

III. LITERATURE ON PRESENT DAY FIREWORKS

The most obvious use of fireworks today is, of course, for the Fourth of July. A surprisingly small number of pictures and stories of these shows ever reach newspapers and magazines. The Literary Digest[29] carried the story of John Adams' advice that the winning of the revolution should be celebrated with " . . . pomp, bonfires, and illumination." An article in the Christian Science Monitor[30] explains that it is because the fall of Vicksburg coincided with the national birthday that the South does not like to celebrate the Fourth of July, but chooses the year-end holidays to blow off fireworks. Life found some other occasions to photograph fireworks, such as the races,[31] New Year's Eve on Pikes' Peak,[32] and a demonstration by the English Navy.[33] The New York World's Fair received some attention for its pyrotechnical displays in the Magazine of Art,[34] Life,[35] and the New York Times.[36] The only other major displays in recent years were held at the opening of the San Francisco Bridges and the Golden Gate Exposition. These were covered by The San Francisco News, The San Francisco Chronicle, The Oakland Post Enquirer, The Oakland Tribune, and The San Francisco News.[37] Some of the best material on current displays appeared in the Popular Mechanics Magazine. It carried good articles in July, 1924,[38] 1936,[39] 1935,[40] and 1938.[41] In 1921 Gardner Teall wrote a short article called "Halinitropyrobilia." Although he failed to spell his title correctly, he offered some interesting information on the derivation of the word pyrotechnics from Pyrodes.[42] The description of a contest for designing a fireworks display is given in The Bulletin of the Beaux Arts Institute of

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[29] "Burning Up $4,000,000 in the Skies," Literary Digest, 122:36, July 4, 1936.

[30] Magazine Section of The Christian Science Monitor, June 29, 1940.

[31] "Life Goes to the Races," Life, 7:70, July 24, 1939.

[32] "Fireworks Blaze Over Pike's Peak Heralding First Sunrise of 1937," Life, 6:21, January 16, 1939.

[33] "The Camera Overseas," Life, 4:68-71, June 14, 1937.

[34] "Symphonies in Sight and Sound," Magazine of Art, 32:290, May, 1939.

[35] "Creation in Fire," Life, 6:40, March 13, 1939.

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[36] The New York Times (World's Fair Section), March 5, 1939.

[37] The references are broadly scattered throughout the magazines and newspapers mentioned between 1936 and 1938.

[38] "Painting the Sky with Powder," Popular Mechanics, 42:19-22, July, 1924.

[39] Paul Paddock, "Staging Plays in Fireworks," Popular Mechanics, 46:82-86, July, 1926.

[40] "Painting with Fire," Popular Mechanics, 64:20-21+, July, 1935.

[41] "Spectacular Fireworks Turn Night into Beauty," Popular Mechanics, 70:9-16+, July, 1938.

[42] Gardner Teall, "Halinitropyrobilia," The Weekly Review, 5:19, July 2, 1921.

Design.[43] The drawings submitted by the first award winners are shown.

IV. LITERATURE ON AESTHETICS AND PSYCHOLOGY

In discussing the nation's birthday The Christian Science Monitor says:

> Fireworks still are recognized as a method of release from the humdrum of the workaday world. Even fireworks put on by the municipality . . . are another form of art, expressions in color and flame and brilliance with a distinct thought behind the whole, which have a value comparable to that of the art gallery or motion picture theatre.[44]

This is clearly a recognition of the aesthetic contribution of fireworks displays from the psychological standpoint. Of all the material read on the psychology of aesthetics the writer found Mauron[45] the most useful. He deals with the intangible qualities of art and beauty in a sympathetic, yet understandable way. H'Doubler[46] and Ames[47] provide material of value for application to an analysis of artifices.

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[43] Robert S. Hutchins, "A Pyrotechnic Display," The Bulletin of the Beaux Arts Institute of Design, 12:3-4, February, 1937.

[44] The Christian Science Monitor, June 29, 1940.

[45] Charles Mauron, Aesthetics and Psychology (London: Hogarth Press, 1935), 110 pp.

[46] Margaret N. H'Doubler, Dance (New York: F. S. Crofts and Company, 1940), 200 pp.

[47] Van Meter Ames, Introduction to Beauty (New York: Harper and Brothers, 1939), 279 pp.

The key reference book for an analysis of aesthetics was Raymond Stites, The Arts and Man.[48] He gets back to the most basic origins of the satisfaction of beauty, sources of design, and development of skills. From primitive art, as Stites defines it, the writer was able to draw parallels with early pyrotechny and follow through to the present day. Oscar Hagen[49] substantiates many of Stites' statements. Ruskin,[50] Raymond,[51] and Munro[52] were of value in the same way.

In trying to find another art form with which to compare feu de joie, the most likely seemed to be the ballet. The performance is something which must be enjoyed at the moment, in the place where it is produced, and without hope of returning to anything within a given performance for second consideration. Surely the following description of ballet could be mistaken for that of a fireworks display by the mere substitution of a word.

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[48] Raymond S. Stites, The Arts and Man (New York: McGraw-Hill Book Company, Inc., 1940), 872 pp.

[49] Oscar Hagen, Art Epochs and Their Leaders (New York: Charles Scribner's Sons, 1927), 322 pp.

[50] John Ruskin, Modern Painters (New York: John Wiley and Sons, 1873), 5 vols bound in 3.

[51] George Lansing Raymond, Proportion and Harmony of Line and Color (New York: G. P. Putnam's Sons, 1899), 459 pp.

[52] Thomas Munro, Scientific Method in Aesthetics (New York: Norton and Company, Inc., 1928), 101 pp.

> One of the chiefest charms of the ballet is its endless revelation of new and unsuspected loveliness . . . if words could adequately describe the loveliness and significance of the ballet there would be no need in going.[53]

H'Doubler,[54] Armitage,[55] and Deacon[56] provided other fragments which were applicable to the discussion of aesthetics in pyrotechnics.

That fireworks have proved an inspiration to other arts is shown by Igor Stravinsky's short orchestral fantacy *Feu d'Artifice* which is so good that it led Diaghileff to commission him to orchestrate some music for the Russian Ballet season.[57] Additional descriptions of the *Fireworks Music* were found in Thomas's *International Cyclopedia of Music and Musicians*.[58] Thomas also mentions Handel's compositions for the Peace of Aix-la-Chapelle. Streatfield[59] quotes some interesting letters from people who heard the performance. McKinney and Anderson[60] also mention Handel's fondness for fireworks.

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[53] Irving Deacon, *To the Ballet* (New York: Dodge Publishing Company, 1935), p. 26.

[54] H'Doubler, *loc. cit.*

[55] Merle Armitage, editor, *Martha Graham* (Los Angeles: Kistler, 1937), 146 pp.

[56] Deacon, *op. cit.*, 173 pp.

[57] Igor Stravinsky, *Stravinsky, an Autobiography* (New York: Simon and Schuster, 1936), p. 38.

[58] Oscar Thomas, editor, "Fireworks Music," *The International Cyclopedia of Music and Musicians* (New York: Dodd, Mead and Company, 1939), pp. 548-49.

Perhaps the extent of fireworks displays is diminishing, but they continue to play a part in the art and entertainment life of people today.

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[59] R. A. Streatfield, Handel (New York: John Lane and Company, 1909), 366 pp.

[60] Howard D. McKinney and W. R. Anderson, Music in History (New York: American Book Company, 1901), 480 pp.

CHAPTER III

EVOLUTION OF PYROTECHNICS

I. PYROTECHNIC BACKGROUNDS

Fire is an active principle which runs through each of the phases considered here as factors in the evolution of fireworks. Fire was an important part of the primitive man's daily life. It was the center of his existence. Its possession and the task of caring for it was one of the features distinguishing man from the other primates.[1]

Fire characterizes no single activity more than another. It can hardly be called a substance necessary to the development of pyrotechny because it is more nearly a process. Nevertheless it plays a part in every phase of the evolution. For these reasons fire has not been considered in a separate section.

Activities encouraging the development. The tracing of the evolution of pyrotechny should here be considered only as a background for an analysis of possible art qualities in the displays today. The writer has taken the liberty to consolidate references which contain suggested paths of the discovery, growth, and development of the pyrotechnic art[2] and to elaborate on them. It is difficult to determine the origin of fireworks without considering their principle element,--combustion. The most is known about inflammables through science, an experimental field which had its beginnings in the investigations by alchemists into the nature of matter. Alchemy itself seems to have been a more or less deliberate effort to apply the doctrines of religious mysticism to chemical and physical phenomonon in accordance with the principle of analogy.[3] Alchemical practices were the outcome of a bit of scientific thinking. Circumstances led some individuals to believe that combinations of forces outside the condescension of the gods were the sources of natural phenomona, rather than the religious sacrifices and persuasive ceremonies which were thought to be the causes. Among the gods credited with such powers by the remainder of the people were the Sun God and the God of Fire. In many accounts of primitive fire festivals there is but a thin line between the sumbolism of fire for the sun and the efficacy of the fire itself. Many of these ceremonies had their origin in the practices of magic.[4] Frazer points out the likelihood that magic arose before religion since man probably tried to bend nature to his will by the force of spells before he tried coaxing a diety with prayers and sacrifices.[5] Behind this whole sequence of development was the element of fire which from very early times was a part of man's social structure. These phases did not follow one another in clear cut succession but mixed and intermingled, and continued to work upon one another well into the scientific era.

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[1] Walter Hough, Fire as an Agent in Human Culture (Washington: United States Government Printing Office, 1926), Preface xii.

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[2] A. St. H. Brock, Pyrotechnics (London: Daniel O'Connor, 1922), pp. 1-6; also Henry B. Faber, Military Pyrotechnics (Washington: United States Government Printing Office, 1919), I, 18-39.

[3] H. Stanley Redgrove, Bygone Beliefs (London: William Ryder and Sons, Ltd., 1920), p. 127.

Magic. The purposes behind practices of magic seem to be numerous. Black magic is magic with evil intent, white magic is beneficent, celestial magic takes its power from planet control, and goetic magic gains power by a compact with the devil. It is most frequently natural magic with which pyrotechny deals and its power comes from employing physical means of a kind not commonly known; thus, it is the most scientific one in the group of magic arts.[6] Pyromancy, the belief in the magic properties and powers of fire itself, may be another one of the roots. One ceremony based on this belief follows:

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[4] Faber, op. cit., p. 29.

[5] Sir James Frazer, The Golden Bough (abridged, New York: The Macmillan Company, 1930), p. 55.

[6] Faber, op. cit., p. 32.

> The Abenakis and Algonkians are much addicted to pyromancy. They make charcoal of cedarwook, which they pound and reduce to an almost impalpable powder, and which they spread out in a certain way, after which they touch fire to it and devine by the way in which the fire runs.[7]

The belief that another world exists, that ghosts and hauntings are a certainty and that emissaries of these beliefs, at one time called magicians and sorcerers, wielded some sacred and awful power for good and for evil seems always to have appealed to human nature.[8] Even today we have seers and clairvoyants, many of whom impress their followers by the use of natural phenomonon and tricks of scientific origin scarcely creditable to a spirit world, but convincing to those ignorant of the methods used. It seems probable that many of the ancient emissaries were as awed by the unexplainable natural occurrences as those to whom they ministered.

Probably one mystery was the will-o'-wisp which we know to be a luminous meteor. Another was the now explainable greenish light which often can be seen over graveyards. The locale plus the eerie appearance invested the light with evil importance. Activity around the resting place of the dead meant but one of two things. It meant either movement of the bodies or of the souls of the bodies buried there. The possibility of the return of the body or soul, because of a spell placed on it, was not a pleasant thought, even to a primitive man. The primitives did not realize that rotting vegetable and animal matter often produces gaseous emanations. Saint Elmo's fire, often called the fire of Castor and Pollux, is now known to be just electrical manifestations due to weather conditions.[9] Today it seems only natural that unusual weather might cause out of the ordinary circumstances such as prostration, the spoiling of food, and skin discomforts. Ancestral man was likely to consider that one of these occurrences caused another, rather than that all were the result of some larger unseen force.

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[7] Hough, *op. cit.*, p. 182. Quotation from Lafitau, *Moeurs des Sauvages Americaines* (Paris: n.p., 1924), p. 387.

[8] C. WC. W. Olliver, *An Analysis of Magic and Witchcraft* (London: RideRider and Company, 1928), p. 2.

It was with these very intangible factors that the first magicians of natural magic began to work. Since many of them were men of learning, they were more interested in increasing their own knowledge than in influencing the lives of their fellow man by incantations. Fire was important to these magicians for they soon discovered that it had the property of changing the appearance and condition of many things without destroying them. This was of particular advantage to their experiments on the transmutation of metals, the goal toward which these workers in natural magic were constantly lured.

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[9] Faber, op. cit., p. 23.

Believers in practical magic also were aided by fire. Two assumptions can be considered the bases of practical magic. First, that like produces like; and second, that things once in contact with one another continue to act on each other after the physical contact has been severed. The motivating idea, as well as the error in the first, is that things which resemble each other are the same. In the second, the idea and error is that things once in contact are always in contact.[10] Often the two ideas are fused in one application as follows: The one wishing to make the spell takes parts of the body of the intended victim such as nails, hair, and spittle, things once in contact with him, and includes these in an image which is in the likeness of the victim. This is then scorched over a fire for seven nights, assuring the powers that be that "It is not the image I am scorching, it is the heart, liver, and spleen of So-and-So that I scorch." The figure is burned after the seventh time and the victim is supposed to die.[11] The magic here is made both by using items that have been in contact with the victim and by doing harm to a likeness, supposing that similar things are the same.

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[10] Frazer, op. cit., pp. 11-13.

[11] Ibid., p. 13.

Fire was also used for divining meaning from the movement of the flame and direction of the smoke. Such activities gradually led to definite information about the combustibility of many substances and with this knowledge the magicians could produce flames of extraordinary violence, controlling the simpler color effects as well.[12] To the ignorant followers this was nothing short of miraculous and their attitude gave increased prestige to the magicians and men of religion who soon were practicing side by side.

Magical control of the sun was often attempted during an eclipse. Some groups shot fire tipped arrows into the air to rekindle the dying sun, others, who did the same things, thought that they were helping to drive away the savage beast with which the sun was struggling.[13]

The references to fire are numerous on the pages of magic literature and a few can be inferred to be simple fireworks. Some material in the more recent writings identify the artifices by name. Philostratus, in compiling the works of his teacher Appollonius, who lived in the first century of our era, tells of the marvels to be seen in India.

> In the river Hyphasis is a creature like a white worm which yields when melted down a fat or oil which once

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[12] *Ibid.*, pp. 38-39.

[13] *Ibid.*, p. 78.

> set afire cannot be extinguished and which the king uses to burn walls and capture cities.[14]

Thorndike, in reviewing this work, suggests that this may be an early description of Greek fire.[15] In the treatise Secretum Philosophorum experiments are included for "making fireworks, softening steel, driving cows," et cetera and the fireworks described seem to be a rocket and some sort of an explosive.[16] This manuscript is thought to be English in origin and of the 13th century.[17] In discussing a treatise presumably of the fourteenth century, Thorndike explains that, although many of the recipes aimed at magical or optical illusions, some of the effects were perhaps more akin to modern fireworks and were chemical rather than magical. Especially was this true of the latter directions in the paper which included one for Greek fire and other explosives which perhaps included gunpowder.[18]

The gradual recognition of the inefficacy of magic brought about considerable change in the minds of those intelligent enough to grasp the idea. In fact, by the sixteenth century, John Fontana was found to be

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[14] Lynn Thorndike, A History of Magic and Experimental Science (New York: The Macmillan Company, 1923), I, 256.

[15] Greek fire was a liquid composition which was thrown as projectiles in vessels or squirted by soldiers. It burned violently.

[16] Thorndike, op. cit., p. 791.

[17] Ibid., p. 788.

[18] Ibid., pp. 236-37.

> . . . using his chemical and physical knowledge and mechanical ingenuity deliberately to feign magical illusions and rather boasting of the reputation for dealing with demons which he thereby acquired . . . his writings . . . showed a tendency toward the mystic and theatrical. . . .[19]

In order to delude a monk who was over-interested in understanding his experiments, he is said to have made a magic candle which alternately rose and sank while burning on water. In his works he tells how to shoot a rocket which "appears like a dragon belching fire and leaving a stench behind."[20]

So fireworks continued in the practices of magic after the devotees were well aware of the futility of the art. It was often from this group that the pseudo-scientists of alchemy arose. With many of them magic and science went hand in hand.

Fire-worship, kindred activities, and remnants. Fire was at the same time man's universal slave and his universal master. It was a protection at night, a convenience and a comfort in the daytime, and a devastating force when rampant. Its loss meant waiting on nature, for in the very early periods lightning was the most likely source of new fire. First, primitive man had to wait for a storm to brew, hoping for accompanying lightning. Then he had to search for the place where fire had struck if there had been such good fortune as a direct hit. Finally, he had to collect and transport the treasure safely back to the tribal headquarters. Each and all of these occurrences lent themselves well to supplication for guidance and assistance from whatever powers might cause the phenomenon. It is quite understandable that the reverence remained when man discovered how to kindle his own fires, whether by sparks from rocks or by the fire-drill method.

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[19] *Ibid.*, p. 175.

[20] *Ibid.*, p. 174.

Traces of the fire cult are observable in all religions.[21] Primitive man seems universally to have worshipped a Sun God and employed fire as the god's sign and instrument.[22] There was a deep philosophy underlying this earliest worship of the world. Fire is probably one of the most accessible of the earth's energies and the greatest within the range of man's needs, for while wind and water change nothing, fire is a transforming agent.[23] The devotions practised in the religious ceremonies made it inevitable that the priests should cultivate a knowledge far beyond that of their people concerning the secrets of nature and the manipulation of the elements. Such information was well used by them to mystify their followers and to justify their claims of miraculous powers. In the words of Faber:

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[21] Hough, *op. cit.*, p. 131.

[22] Faber, *op. cit.*, pp. 17-18.

[23] Hough, *op. cit.*, Preface xi.

> The priests by varying flames and narcotic fumes of incense . . . showed themselves ambassadors of the god, master of his symbol, the flame. . . . The people saw the alter fire kindled at a mere word spoken by the minister, saw it flash into flames that changed color miraculously, saw it die at another command. . . .[24]

So the spectacular was early esteemed for its emotional effect in arousing the devout. The priests were discovering that certain substances could be treated in such a way as to result in combustion of extraordinary energy, and it was probably from these discoveries that pyrotechny had its beginning.[25] Tradition holds that the rocket was originally devised by these ministers of the divine. It was claimed to be the living spirit of the flame which, at the priest's command, by its own power mounted to heaven as a messenger to the fire god.[26]

Customs and ceremonies only partially religious, similarly called for the use of fire in earlier times. Among our American Indians one group concluded the initiation ceremony of their youth by hurling a ball of grass to the ground. The ball was constructed to burst into flames when it struck, symbolic of lightning.[27] The marriage rites also were influenced. Torches and other methods of illumination are frequently referred to in classical Roman writings, the custom being to conduct the bride in the night to the home of the bridegroom by the light of many torches.[28] Notes from Aboriginal Siberia[29] show that the bridegroom, on entering his new abode, was expected to kindle a new fire with his flint and steel. By the manner in which the sparks flew the couple's future was foretold.

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[24] Faber, op. cit., p. 29.

[25] Faber, op. cit., p. 31.

[26] Ibid., p. 57.

Numerous references seem to indicate a probable sex linkage with the customs and ceremonies surrounding fire and the worship thereof. Agni,the Hindu divinity, according to the legend, was born a baby from the friction of two sticks. That fire is a symbol intimately connected with passion is further indicated by the tradition that Thursday is the best day to marry. Thor, whose name this day bears, was the god of fire.[30]

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[27] Hough, op. cit., p. 145; quoted from Alice C. Fletcher and Francis La Flesche, The Omaha Tribe, 27th Annual Report of the Bureau of American Ethnology, 1911.

[28] Hough, ibid., p. 153.

[29] Loc. cit., quoted from M. A. Czaplicka, Aboriginal Siberia, 1914.

[30] Faber, op. cit., p. 19.

Among the ancient gods connected with fire whose names are today familiar to us are Baal, the Chaldaean and Phoenician god of Fire, the Egyptian Amen Ra, more specifically connected with the sun, and Gibil, the Assyrian Fire God. In Mexico, appropriately enough for a volcanic region, there is also a lord of fire. He is Ziuhtecuhtli, often referred to as the "Lord of Comets."[31] The Rosacrutians and Zoroastrians were believers in primordial fire, assuming that the world was created by fire, the divine spirit of which was an omnipresent God.[32] Zoroaster was the agent promoting fire and nature worship among the Persian tribes. His was a monotheistic religion whose supreme being was Ahura Mazda. Light was the essence of Ahura Mazda. Accordingly the sun, as chief source of perceptible light, was chosen as the best symbol of the diety. The nearest approach to temple edifices which were ever erected by the Zoroastrian sect were small sacred fires placed on mountain tops, somewhat apart from human habitation.[33]

Even in the Christian religion fire is an important symbol. "Let there be light" is a familiar phrase. Adam and Eve were driven from the Garden of Eden by a flaming sword and the Children of Israel were guided on their journeying by a cloud by day and a pillar of fire by night. Soddam and Gomorrah were destroyed by a rain of fire. Moses talked to the Lord represented by a burning bush, and Elijah was carried to heaven in a chariot of fire.[34] Descriptions of wheels, rivers, and thrones of fire seem preferred by the writers of the Holy Script. Their reason may have been the extreme appropriateness for fire to represent God. Everything has the capacity to be illumined and burned, so fire is in all things yet the capacity is normally hidden. Similarly God is everywhere but He is invisible. Fire can pass thru everything without losing its own character. Correspondingly, God can conquer all things but is above influence.[35]

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[31] Hough, op. cit., p. 126.

[32] H. P. Blavatsky, Alchemy and the Secret Doctrine (Wheaton, Illinois: Theosophical Press, 1927), p. 119.

[33] William Montgomery McGovern, The Early Empires of Central Asia (Chapel Hill, North Carolina: University of North Carolina Press, 1939), pp. 83-84.

Some practices and feast or holidays of the Christian Church can be traced to sources in the earlier fire and nature worship. For example, there was an annual festival for Diana held the thirteenth of August, the hottest time of the year, during which her grove was lighted with multitudes of torches, whose ruddy glare was reflected by the lake. Once some unknown dedicated to her a perpetually burning lamp in a little shrine, for the safety of the Emperor Cladius and his family. Many other lamps have been found in the grove, presumably used likewise by humbler persons. Frazer says that the dedicating of holy candles in the Catholic church is a close analogy of this custom.[36]

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[34] Faber, op. cit., p. 24.

[35] Katherine Everett Gilbert and Helmut Kuhn, A History of Esthetics (New York: The Macmillan Company, 1939), pp. 142-43.

The burning of an effigy of Judas on Easter is not based on the teachings of Christ or his disciples. It seems to be a vestige of the old ceremony for kindling new fire at the summer solstice. The practice is still carried out by the Incas of Peru and the Indians of Mexico. The Chinese, also, yearly put out all their fires for three days around the first of April and renew them solemnly one hundred five days after the winter solstice.[37] Britton points out that:

> The women who have wept for Tammaz, the Syrian Sun-God, the mourners who have lamented with Isis for the Egyptian Osiris, the Greeks who have wandered with Ceres in search of the lost Proserpina, the devotees who have wailed for the slain Chrishna, one of the Sun Gods of the Hindoos, and the Marys who weep at the sepulchre for the Christ of the Jews, all the nations of antiquity throughout the Orient--each of whom, under many names and in many forms, have adored the Sun-God and believed in his annual birth, life, death, miracles, and resurrection--all have united to celebrate the new birth of idol on the twenty-fifth of December, the period at

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[36] Sir James George Frazer, The Golden Bough (New York: The Macmillan Company, 1935), I, 12.

[37] Frazer, *op. cit.*, 1935, X, 131-37.

> which the solar orb actually passes thru the constellation of the Zodiacle sign of Capricorn, or "the renewer of life."[38]

The most common fire festival held in Europe during the summer solstice is that of Midsummer Eve or Day, the twenty-third or twenty-fourth of June. This has been given a faint tinge of Christianity by naming the day after St. John the Baptist, but the celebration obviously dates from long before the beginning of our era.[39]

Among the bonfire celebrations held today which are linked with the Church many are probably relics of paganism. Seasons of the year when bonfires are most commonly lit are spring and midsummer. In a few places the end of autumn and during the winter, especially on Hallowe'en, Christmas Day, and the Eve of Twelfth-night, there are scenes of bonfires.[40] There are two different explanations of these bonfire festivals. One is the solar theory which holds that the fires were originally kindled to mimic on earth the great source of light and heat in the sky. The purpose was to insure a needful supply of sunshine for men, amimals, and plants. The purification theory is the other explanation.

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[38] William Britten, Art Magic (Chicago: Progressive Thinker Publishing House, 1898), p. 49.

[39] Frazer, op. cit., 1930, p. 622.

[40] Frazer, op. cit., 1935, X, 106-7.

Supposedly the fire burned up and destroyed all the evil influences which had collected during the year, whether in personal form or in impersonal taints in the air.[41] Today most of the early significance has disappeared but the fires persist because of the established customs of the people.

Bonfires are commonly lit the first Sunday of Lent in Germany and Austria. In Swabia on this day they burn a witch of straw while at the same time the young people hurl blazing discs into the air.

> The discs are thin round pieces of wood, a few inches in diameter, with notched edges to imitate the rays of sun or stars. They have a hole in the middle by which they are attached to the end of a wand. Before the disc is thrown it is set on fire, the wand is swung to and fro and the impetus thus communicated to the disk is augmented by dashing the rod sharply against a sloping board. The burning disc is thus thrown off, and mounting high into the air, describes a long fiery curve before it reaches the ground.
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> At Wangen . . . the burning discs which they hurl into the air are said to present in the darkness the aspect of a continual shower of falling stars.[42]

In Tyrol on the first Sunday of Lent a slender young fir tree has a pile of straw and firewood placed around its base and at the top of the tree is fastened a human figure, called the witch, which is made of old clothes and stuffed with gunpowder. All of this is then burned.[43]

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[41] Frazer, op. cit., 1930, p. 642.

[42] Frazer, op. cit., 1935, X, 116-17.

[43] Frazer, op. cit., 1930, p. 612.

Among the festivals which were most obviously for destroying or repelling witches to whose malificent art the people blamed most of their troubles, is the Hallowe'en celebration. Like the Celtic May Day, this seems to bear no relation to the position of the sun in the heaven, but rather to mark a terrestrial division in the year according to the beginning of winter weather when the cattle returned to the homestead. Hallowe'en seems to have been the Celt's New Year celebration for numerous devices were used for prying into the future, a reasonable activity for the beginning of the year.[44] Both the fires and the fortune telling have been carried down to our modern Hallowe'en parties. Life Magazine shows pictures of fireworks being set off from the top of Pike's Peak at the birth of 1939 in America.[45]

The featuring of fire in tribal ceremonies nearly disappeared with the discontinuance of tribal organization. The original meaning was lost, but occasions for rejoicing were celebrated with bonfires called *feu de joie*.[46] This name has now come to mean fireworks.

Alchemy. The words alchemy and chemistry in their etymological origin describe different stages in the progress of the same science.[47] Alchemy itself was transitional between an animistic system where spirits were believed to control natural phenomena and the positivism of of the scientific era.[48]

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[44] *Ibid*., pp. 631-34.

[45] "Fireworks Blaze Over Pike's Peak Heralding First Sunrise of 1939," *Life*, 6:21, January 16, 1939.

[46] Hough, *op*. *cit*., p. 144.

The alchemical doctrines began with the belief that all matter was "one." Metals were thought to be composed of sulphur and mercury in variable quantities condensed by means of a salt. Different metals were the result of varying quantities of these three materials. The explanation of the existing variety of metals was the idea that minerals were the fruit of mineral nature. The baser metals were unripe fruit that had been cut from the tree of life before the sulphur and mercury had been combined and ripened in the right proportion. The Philosopher's Stone for which they were all searching was a ferment which would ripen or hurry along the process of nature in transmuting baser metals into gold.[49] Gold was considered the intended fruit of nature because it was the most beautiful metal, untarnishable, and unaffected by sulphur and most acids.[50] Beside its ability to transmute metals, the Philosopher's Stone was also considered the agent for the purification of all matter, the universal panacea.[51] Alchemy actually did much for medicine, man's mastery over the field of elements, and his insight into the general mode of action of the chemical forces of nature.

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[47] W. A. P. Martin, The Lore of Cathay (New York: Fleming H. Revell Company, 1901), p. 44.

[48] Olliver, op. cit., p. 190.

[49] Ibid., p. 203.

[50] Stanley H. Redgrove, Bygone Beliefs (London: William Rider and Sons, Ltd., 1902), p. 132.

The exact beginnings of alchemy seem rather obscure. Around 600 B.C., Taoism began in China. This faith regards body and soul as identical in substance and holds the idea that their dissolution may be prevented by a course of physical discipline. This same philosophy is the seed thought of Chinese alchemy, for it was this materialistic notion which first led Laotze's disciples to investigate the properties of nature.[52]

There are also evidences that the ancient Egyptians practiced alchemy in its metalurgical forms. In fact it was a part of the secret Egyptian initiations practiced exclusively by the priests.[53] The valid history of alchemy in the western world, however, probably began about the time of the fall of the Roman Empire.[54]

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[51] Olliver, op. cit., p. 191.

[52] Martin, op. cit., p. 52.

[53] Olliver, op. cit., p. 204.

[54] Right Reverend J. E. Mercer, Alchemy: Its Science and Romance (London: Society for the Promulgation of Christian Knowledge, 1921), p. 104.

The three principles, which alchemists assumed existed in metals, echoed their belief in religious trinity. Each metal had a body, soul, and spirit. The body was represented by salt and was relatively unimportant; mercury was symbolic of the spirit or intellect, evidenced by its brightness; and the counterpart of the soul was sulphur, the principle of combustion and color. Inward sulphur was equivalent to the love of God and the most essential factor to the development of the metal. Outward sulphur or self-love, was the chief cause of impurities. The reason that all metals except gold and silver were affected by fire was that they contained outward sulphur.[55]

These principles had color symbols as well. Black represented the dark soul of self-love; white was symbolic of the new intelligence shown in God-love; red was equivalent to the contemplative life, or perfection.[56]

Physiologically, alchemy held the tenets that man was composed of four basic humours in a manner similar to that of the earth; man's humours were bile, blood, phlegm, and blood bile. For example, fire caused hotness and dryness on earth; bile caused it in man. Sulphur represented the fire element so people suffering with chills were given sulphur.

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[55] Redgrove, op. cit., pp. 133-34.

[56] Ibid., pp. 141-52.

Fever indicated an excess of bile.[57] All these, then, were the basis for alchemical experimentation.

A few names stand out in the history of alchemy for their scientific contributions or knowledge in advance of the times. Perhaps the most familiar name of all among this list of quasi-scientists is Hermes, considered by alchemists as the father and originator of science. "Hermetically sealing," so commonly used today, is a relic of the time when all ingredients were kept in flasks closed with wax bearing an impression of the seal of Hermes on them.[58] Geber, the Arabian, in the eighth century, recorded his acquaintance with sulphuric acid and aqua regia. There was Albertus Magnus who showed by his writings an understanding of the purification of gold and silver by means of lead. Roger Bacon in the thirteenth century described with considerable accuracy the properties of saltpetre, giving a recipe for gunpowder and coming very near to the explanation of the function of air in combustion.[59] With his knowledge of gunpowder he is credited with having occupied his leisure in making fire crackers for children and rockets with bursting charges for the older boys though he looked forward to the use of his explosives for the defense of the state.[60] Raymond Lully, also of the thirteenth century, described a process for obtaining essential oils, and Brandt, while analyzing the human body in search of the Philosopher's Stone, stumbled on the discovery of phosphorous.[61] Thus, as Faber summarizes the situation:

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[57] Ibid., pp. 29-33.

[58] Olliver, op. cit., p. 191.

[59] Martin, op. cit., pp. 45-46.

> . . . by devious ways through a progress of ages, the art of fire has brought about that perfection of scientific labor we know as chemistry, and now, in its turn, chemistry becomes the minister of pyrotechny, the art of aerial fire--for those important developments already begun, and for those others destined to multiply amazingly in the future.[62]

Substances leading to the development. Many writers of pyrotechny books feel that, in general, the public credits the development of fireworks to the invention of gunpowder. They offer much evidence that this belief does not represent the truth. The authorities agree that the ingredients needed in fireworks are the same as those of gunpowder, being sulphur, saltpetre (potassium nitrate), and carbon. They agree that these ingredients must be combined, and in similar proportions, but the resultant composition is not gunpowder because the ingredients are not as thoroughly mixed. Combustion therefore spreads over a greater interval of time, only the exposed surface being consumed, instead of the whole mass being utilized at once.[63] Pyrotechny is more likely based on the discovery of the assistance saltpetre gives to combustion than on the discovery of gunpowder.[64]

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[60] Lieutenant-Colonel Henry W. L. Hime, The Origin of Artillery (New York: Longmans, Green and Company, 1915), p. 113.

[61] Martin, op. cit., p. 46.

[62] Faber, op. cit., p. 37.

It is only natural to presume that the attention of the ancients would be attracted by the efflorescences which form on certain stones, walls, caves, and cellars. They must have noticed the deflagration of at least one of these when a fire was lit on it. Because the various salts are so similar in appearance and taste, none but common salt was identifiable from the others at an early date. No reliable recognition of saltpetre appears before the thirteenth century.[65] India and China have much saltpetre (called nitrate of potash) and being a salt it was probably used at an early date for curing meats. When bits of it chanced to drop into the fire the added brilliance was certain to be noticed and probably brought about one of the first chemical experiments. Since it made the fire burn brighter it was undoubtedly used as a tinder. The most accessible combustible material to mix with the substance was charcoal, and in putting these two together the first steps in pyrotechny had been taken. Skill in the practice of making fire may well have had considerable social significance, perhaps leading to the job of firemaker for the tribe.[66]

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[63] Brock, op. cit., p. 90.

[64] Ibid., p. 5.

[65] Hime, op. cit., p. 11.

Similarly it is possible that in making fire by striking iron pyrites on flint, small pieces of reguline particles of iron were detached, falling unlit into the fire mixture. When combustion of the entire body of fire mixture took place, the pieces of metal would scintillate as iron filings do in modern fireworks compositions. It is probably that this is the way the composition known as Chinese Fire was gradually evolved. It was known in the East from remote times.[67]

Martin says, in attempting to find the earliest dates for gunpowder:

> Gunpowder which Sir James MacKintosh brackets together with printing as securing our nation against another invasion of barbarians, is, in my opinion to be set to the credit of the Chinese. The honor is contested by English, German, Arab, and Hindu; nor is it impossible that the discovery may have been made independently by each. Its ingredients sulphur, nitre, and carbon, were in constant use by alchemists, and it was inevitable that the explosive force of the composition should have been found out if only by accident- especially as no fixed proportion is required.

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[66] Brock, op. cit., p. 3.

[67] Ibid., pp. 4-5.

> The first to meet with this happy accident would be the Chinese, who were the first experimenters in the field of alchemy.
>
> As for the Arabs, they were transmitters, not inventors. The only people who can seriously compete with the Chinese are the Hindus. Their knowledge of gunpowder is certainly of great antiquity but their ancient dates are difficult to fix and the balance of the evidence appears to be in favor of China.[68]

Though gunpowder may have been known from ancient times, its use as a propellant was not discovered until well into the Christian era. Although there are early passages which seem to prove the use of firearms and gunpowder, they refer in reality to Greek fire and similar compositions used as projectiles. The materials were thrown from machines or catapults, not propelled by internal combustion. The mixtures were probably pitch, resin, solphur, and crude saltpetre, encased in hollow stones, iron vessels, or in the ends of arrows. Such a combination was frequently called Naptha.[69]

It is quite possible that the introduction of Greek fire into western Europe by returning Crusaders brought about the perfection of gunpowder. Although not the source of fireworks, gunpowder gave a great impetus to experiments with aerial fire.[70] From then on ingenuity was the greatest single contribution to pyrotechnics till the introduction of color technique around the middle of the nineteenth century.[71]

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[68] Martin, _op_. _cit_., p.24.

[69] Brock, _op_. _cit_., p. 6.

[70] Faber, _op_. _cit_., p. 40.

II. PYROTECHNICS PROPER

Pliny records that Pyrodes was the first to strike fire from flint.[72] Pyrodes, in Greek, means "firelike." Obviously Pyrotechny derives the name from the same root.

Historical development of fireworks. Fireworks making is of great antiquity, the date of its origin remaining quite unknown. The art was practiced in the East from very early times and attained the highest degree of perfection in China and Japan. Although Chinese records of fireworks antedate any others, it is quite possible that their knowledge had its source in the penetration of primitive culture from Egypt into the Celestial Kingdom. The Egyptian culture then passed away and the only remaining traces of the ancient learning were those preserved on the stone monuments. A few vestiges of their culture survived the changing dynasties in India and China, and there alone the cultivation of pyrotechnics was maintained.[73]

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[71] Brock, op. cit., p. 74.

[72] Gardner Teall, "Halinitropyrobilia," The Weekly Review, 5:19, July 2, 1921.

[73] Faber, op. cit., p. 39.

When Rome began to dominate the known world, it collected every variety of luxury and art for the fullness of life. Silk was imported from China, jewels from India, and a knowledge of fireworks from the Orient. The fireworks were used for displays in the Circus for such Emperors as Augustus and Diocletian, and the art of aerial fire was given new energy. The overthrow of Rome put a stop to the development of pyrotechnics for roughly five hundred years, the only development in the meantime being Greek fire. The Crusaders were introduced to this material of war and took the information back to western Europe. With this knowledge in new hands aerial fire again saw activity and the old spirit of Rome was revived in Italy.[74] The new spectacle was greatly used as an accessory to public pageantry. Siena was renowned for its complicated displays and Italy long retained supremacy in the field.[75]

As Italy's enthusiasm began to wane, England and France took up the art. There was a remarkable growth of scenic effects around the fifteenth and sixteenth centuries. France was especially devoted to Greek mythology and Britain was particularly interested in national narratives. Some places on the continent developed clever interminglings of

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[74] Ibid., pp. 39-40.

[75] "Pyrotechnics," The New International Encyclopedia (New York: Dodd, Mead and Company, 1930), XIX, 405.

Pagan stories and Christian doctrines, diverting fables of the ancients into allegories for the entertainment and instruction of the people. The government of Great Britain took over the active work in pyrotechny at an early date and offered their results to the public on the occasions for special rejoicing. Gradually the displays were marked for the beauty which they provided.[76]

These two factors, an expression for periods of especial rejoicing, and an emphasis on beauty, seem to have remained as the guiding principles in all subsequent pyrotechnical exhibits.

Early historical references. The two oldest forms of fireworks known are firecrackers and the rocket. From antiquity these have changed but little, either in form or composition.[77] About 1881 there appeared a very interesting question in one of the metropolitan examinations in China. It emanated from the chief examiner, one of the most learned men in the Empire. His query was: "Fire arms began with the use of rockets in the dynasty of Chou (B.C. 1122-255)-- in what book do we first meet with the word p'ao, now used for cannon?" Whether or not the rockets referred to were actually used as firearms is a matter open to conjecture, but at least the existence of rockets is confirmed.[78] One of China's best authorities on the subject of inventions cites the fact that in 998 A.D. a Tang Fu produced a rocket of a new style having a head of iron, proof that it was not intended for a mere _feu de joie_.[79] Even today a package of Chinese firecrackers reflects the order of their ancient society. First of all there is the one yellow, or imperial, cracker which stands for the emperor. Various green tinted crackers represent the nobles and the magistrates of the several ranks, called Mandarins. The greatest number, which are alike, and uniformly of a red color, tell of the populace, or common people, who are made of the red earth and to the red earth return.[80]

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[76] Taber, op. cit., pp. 40-43.

[77] Brock, op. cit., p. 91.

The earliest record of European pyrotechnics seems to be Claudius's account of a public festival during the conculate of Theodosius in the fourth century A.D. He describes a scene in which fire "ran about in different directions over the planks without burning or even charring them and which formed by their twisting and turning, globes of fire."[81] _The Dream Book of Daniel_, a manuscript written in 1081 gives directions for performing various tricks and for making fireworks.[82] From a book of the fourteenth century, titled Marvels of the Universe, a recipe is given for making "flying fire."

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[78] Martin, _op_. _cit_., p. 25.

[79] _Loc_. _cit_.

[80] William Elliott Griffis, _China's Story_ (Boston: Houghton Mifflin Company, 1911), p. 65.

[81] Brock, _op_. _cit_., p. 13.

> Take a pound of sulphur, two pounds of charcoal, and six pounds of saltpetre. Grind them very fine on a marble stone. Then put some in a cover of flying paper or thunder-making paper. The cover for flying should be long, thin, and well filled with that powder, but for thunder-making, short, thick, and half filled.[83]

This seems to be a description both of gunpowder and fireworks. There is also a description of a barge used at the coronation of Anne Boleyn in 1538 which carried a dragon "casting forth wild fire--and men casting fire."[84] However primitive, this is obviously a reference to some pyrotechnic effect.

Fireworks displays and the evolution of structure in the sixteenth and seventeenth centuries. The first Europeans to make headway in pyrotechnics proper were the Italians. They held supremacy until the end of the seventeenth century. Italy was especially fond of portraying legends of the Church. The Florentines and Viennese were the first to make fireworks on erections of wood. They constructed elaborate temples and palaces richly decorated with gilding, statuary, and floral pieces, illuminated both from the inside and the outside so as to be seen from great distances. On these, fireworks proper were displayed. Some of the statues, even, threw out fire from their mouths and eyes. The erections were often put up in the great public squares where it was convenient for the exhibitor and for the sightseers, and at the same time eliminated much of the danger of fire.[85] To a large extent the sixteenth and seventeenth century displays were characterized by the use of rockets. There were ground rockets which gave effects similar to the modern fountain or gerb, burning less fiercely than the propellant variety, and remaining stationary. Other rockets were used to turn primitive wheels. Line rockets, having no cap or garniture, were used to cause dragons and other creatures to issue from scenic castles. These usually moved over a tightly stretched rope which passed through the rocket along the lengthened stick.[86] Other moving figures were controlled by means of pulleys. (An example of this is shown in Plate III, page 151.)

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[82] Thorndike, op. cit., p. 804.

[83] Ibid., p. 737.

[84] Brock, op. cit., pp. 16-17.

One writer gives the following list of materials at the disposal of the arranger of fireworks displays at the beginning of the seventeenth century.

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[85] *Ibid.*, pp. 18-19.

[86] Brock, *op. cit.*, p. 97.

Festive artificial fireworks called aerial:

- Simple
  - Moveable, such as rockets
  - Immovable, such as squibs and Roman candles
- More complicated
  - Moveable, such as flying dragons and balls of various kinds
  - Immovable, such as clubs, shields, and towers
- Various balls burning in the water
  - Constructed of linen, wood, or metal
  - Simple, charged with powder only
  - Loaded, with rockets or with smaller balls[87]

In the early French Chronicles, around 1550, there appeared a woodcut illustrating the entry of Henry II into the city of Rouen. The celebration included water sports depicting the antics of the water gods and their attendants and fireworks can be seen coming from the galleys of the floating barges.[88] Similarly a print was made of the display given in honor of the christening of John, Margrave of Brandenburg in 1592. An extraordinary fireworks tournament is being witnessed. Two pair of jousters wielding fiery lances and with squibs issuing from the tails of their horses are engaged in battle. Other encounters between foot soldiers with fiery swords diversify the scene.[89] Among familiar accompaniments to be seen in many of the displays of this time was the "Green Man." John Bates describes him in an account of the procession to the Chester Races on St. George's Day in 1610. The procession began with:

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[87] Hodgkin, *op. cit.*, from "Books on Fireworks," p. 10, translation from Adrianus Romanus, *Pyrotechnia, Hoc Est, De Ignibus Festivus, Iocosis, Artificialibus et Seriis, Variisque eorum structuris*, libri duo.

[88] Hodgkin, *op. cit.* from "Fireworks Displays," p. 45.

> . . . two men in green ivy, set with work upon their other habit with black hair and black beards, very ugly to behold, and garlands upon their heads, with great clubs in their hands, with fireworks to scatter abroad to maintain the way for the rest of the show.[90]

It is possible that these green men were a development from Danish parades which always began with supporters of the Danish Royal Arms worked in as a complement to the royalty. In 1606 the King of Denmark visited James I of England and provided such a display upon his departure.[91]

Another display given about 1610 was of considerable scope, lasting nearly two hours. Part of it represented the fall of the city of Troy. When the wooden horse approached the city walls and towers, parts of them fell down. Greek soldiers poured from the horse and Trojans issued from their town, covered with fireworks. They fought a wonderful fight. The horse projected fire against the city and the city against the horse. It was finished off by one of the most beautiful spectacles in the event, the discharge of eighteen trees charged similarly with fire.[92] At the time of the marriage of Louis XIII in 1615 a display was given at the Palace Royale in Paris. It included combats between men carrying lighted arms, but the fireworks here played a comparatively secondary part.[93] A picture was made of the celebration at the birth and christening of the French Duke of Wurtemberg in 1616. The cut, which is shown in Plate II, page 150, shows a grand central edifice from which an infinity of darting flames are issuing, along with the smoke of a hundred fire pots. In a relatively clear space, men in hats of the Guido Fawkes type are igniting acquatic fireworks on the surface of buckets of water.[94] It is interesting to note the use of the Guy Fawkes hats, symbolic of the near-disastrous gunpowder plot of 1605. Remnants of the day of rejoicing were still popular in England a few years ago and fireworks were used for the celebrations.[95]

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[89] *Ibid.*, p. 46.

[90] Brock, *op. cit.*, p. 17.

[91] *Ibid.*, pp. 17-18.

Lorentz Muller, a master in pyrotechnic art, and his pupil Benedick Loehnner put on a display in Nuremberg in 1635 which included their portraits in oval cartouches.[96] This was something of an innovation.

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[92] Hodgkin, op. cit., "Halinetropyrobolia," p. v, translated from C. J. Menestrier, Traite des Ballets.

[93] Brock, op. cit., p. 20.

[94] Hodgkin, "Fireworks Displays," p. 47.

[95] Struthers, op. cit., pp. 19-24.

At the end of the Thirty Years' War the Peace of Westphalia was held in 1650. That it was adequately celebrated with pyrotechnics is readily agreed upon looking at a cut of the exhibition given at that time. It is a well planned picture, having a dark landscape and sky which provides an excellent foil for the gorgeous display of rockets. In the foreground are countless lesser fires with fire-swords in considerable number. Cannons and mortars are very busy, apparently attempting to make up in noise what they lack in brilliancy. A group of distinguished strangers are watching the Temple of Peace. Toward the temple runs a cord on which a fiery Cupid rushes along, but (as the owner of the print says in describing the scene) "not on an errand of mercy, for he sets the Goddess in a blaze."[97] A similar scene is depicted in Plate IV, page 152.

Around 1655 an engraving was printed in a German text which provided, along with the picture, a detailed description of some twenty different kinds of fireworks. In the center of the display is a large gallows-like erection, in the center of which is a tremendous statue of the monarch. In flames above his head are the letters CR surmounted by a sun. As in the previously pictured events, flying dragons rush to and fro on their tightly stretched lines while a group of artillery furnish sound and flights of rockets add brilliancy to the entertainment.[98] A similar engraving of fireworks at Ulm in 1665 gives a full explanation of some thirty-five varieties.[99]

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[96] Hodgkin, _op_. _cit_., p. 48.

[97] _Ibid_., p. 49.

A daring performance which caused his death was put on by Karls Bermoja, a physician and surgeon, in 1673. He performed on a three hundred foot rope stretched from a tower to the basement of a house, enveloped in squibs and other fireworks, with twenty pounds of powder hanging from his body, limbs, and fingers. He suffered a fall which was fatal.[100]

In describing the picture of the celebration at the coronation of William III and Mary at Amsterdam, Hodgkin says:

> Ships everywhere, some discharging swarms of rockets and cascades of fire, some supporting tar-barrels, others only affording standing room to the holiday makers. . . . You can almost hear the cheers of countless multitudes which throng the bridge, the keys, the windows, the roofs of the houses: whilst water balls

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[98] Ibid., p. 50.

[99] Ibid., p. 52.

[100] Ibid., pp. 53-54.

> and water rockets vie in their ayrations on the surface of the lake. In fine you can hardly help feeling as if you were assisting at an intoxicating spectacle.[101]

Subsequent displays until the introduction of modern color. With the eighteenth century came certain advances in the manufacture of artifices. An engraving of the fireworks display at the celebration for the birht of the Arch Duke Leopold in 1716 shows this clearly. In place of simple rockets, balloons are to be seen bursting, as in present day displays, into beautiful stars and falling showers. Serpents and Roman Candles also have been ignited showing that they were still in great favor. Supporting structures were still in use.[102]

One of the chief causes of progress in France in pyrotechnic skill was the encouragement Louis XV gave to Morel Torre and the Rugierri brothers. The Rugierris were Italians from Bologna. They became naturalized citizens of France and contributed greatly to the development of French *feu de joie*. They were the first producers to rely chiefly on fireworks for their effects instead of using them as embellishments on scenic or architectural structures.[103] There is record of a display given in 1739 on the occasion of Madame La Premiere of France marrying Don Phillipe of Spain which was of purely pyrotechnical pieces.[104] To be sure concurrent developments were in part responsible for this change in the type of display. Until the introduction of quick-match around 1743 much advance in fixed and mechanical artifices of display was not possible. Quick-match is essential for the leading up of set pieces. To produce instant and symmetrical ignition of a piece requires much skill and knowledge. The position of the pyrotechnist in the eighteenth century was similar to that of the artist or sculptor. He carried out his work personally, with the help of trained assistants, and each piece was looked upon as a work of art. Artifices were the personal effort of the pyrotechnic artist.[105]

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[101] *Ibid.*, p. 57.

[102] *Ibid.*, p. 61.

[103] Brock, *op. cit.*, pp. 20-21.

Scientific analysis had not become the whole story at this time, however, for in 1747 Frezier wrote a book analyzing pyrotechnic compositions. The entire work shows the effect of the magic element carried over from the alchemists and the magicians before them.[106]

For celebrating the Peace of Aix-la-Chapelle in 1749 a large scale festivity was held which received considerable comment from numerous sources. The great feature of the affair was the display of fireworks. Handel was commissioned to write music for the event to precede and accompany the exhibit. The major artifice was a machine representing a Eoric Temple, one hundred fourteen feet high and four hundred ten feet long. This was erected in Green Park after a design by Chevalier Servadoni.[107]

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[104] Ibid., p. 21.

[105] Ibid., pp. 124-25.

[106] Ibid., p. 142.

In spite of what seems to be numerous shows, fireworks were a rarity to the majority of the people and everyone who could possibly manage planned on coming to see the display. Horace Walpole wrote his reactions which show that he was not particularly impressed.

> The fireworks by no means answered the expense, the length of preparation, and the expectation that had been raised. The rockets and whatever was thrown up into the air succeeded mighty well; but the wheels and all that was to compose the principal part were pitiful and ill conducted, with no changes of colored fire and shapes. The illumination was mean, and lighted so slowly that scarse anybody had patience to wait the finishing; then what contributed to the awkwardness of the whole was the right pavillion catching fire and being burnt down in the middle of the show.[108]

Hodgkin remarks that it was a popular event, though England had no great reason to be so excited. One reviewer summarized acidly:

> The peace concluded at Aix-la-Chapelle . . . not only generously did restore Cape Breton to the Crown of

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[107] R. A. Streatfield, Handel (New York: Simon and Schuster, 1936), pp. 200-1.

[108] *Ibid.*, p. 201.

> France, sent two of her . . . Nobility as Hostages . . . leave Dunkirk in part still fortified, but also expended in a Fire-work, a sum little inferior to the original demands of Spain, and conclude a Most Gracious and Honorable Peace with that Nation; leaving the grand Affair of the Search, and barbarities used toward her gallant sailors just where she found them. Thus ended this long, bloody, and taxing War; which was opened with Bonfires at home, carried on with Pot-guns in the Field, and ended with the loud Roar of Cannon in the Green Park, the twenty-seventh of April, 1749.[109]

A folio of twelve prints was made of this celebration, but only a few of these depict the night effect. The daylight sky was more frequently used in all such pictures. The picture from this collection which seems to be reproduced most often is the one showing the fire in the right wing of the exhibit. A reproduction of this is to be found on page 154, Plate VI. The title, "The GRAND WHIM for Posterity to laugh at," repeats the note of derision struck by Walpole in his description of the event.[110]

Following the display at Aix-la-Chapelle there was no official exhibit of note for the first thirteen years of the nineteenth century. Then the Peace of 1814 was celebrated. St. James Park was reserved for those who paid admissions to this affair and the display consisted chiefly of aerial fireworks with gerbs, Roman Candles, fountains, and wheels. Few of the devices were of any great size. Repetition of this alone seemed tedious to the crowd.[111] Charles Lamb was not disappointed, for he wrote in a letter to William Wordsworth:

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[109] Hodgkin, op. cit., pp. 71-72.

[110] Loc. cit.

> After all the fireworks were splendid--the Rockets in clusters, in trees and all shapes, spreading about like young stars in the making floundering about in space (like unbroke horses) till some of Newton's calculations should fix them, but then they went out. Anyone who could see 'em and the showers of gloomy rainfire that fell sulkily and angrily from 'em and could go to bed without dreaming of the Last Day, must be as hardened an atheist as xxxx.[112]

Perhaps public disappointment in the show was responsible, in part, for the lack of further official shows, for such an extended period. It is true that many people grumbled about the waste of money.[113] In 1765 Lieutenant Jones complained that whenever there was an occasion for such diversions the people of England always seemed to turn to foreigners for their execution. He was not sure whether this was caused by the people's ignorance or their prevailing fondness for things foreign.[114]

During this time there was some private enterprise. In 1788 Astley Senior advertised to show a double display of fireworks, one in the Royal Grove, and one at Astley's

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[111] Brock, op. cit., p. 41.

[112] Ibid., pp. 40-41.

[113] Ibid., p. 39.

[114] Ibid., p. 31.

Amphitheatre. This was to consist of numerous devices prepared in the usual way to be played off alternately with some newly invented Philosophical Fireworks to be set off by the inventor himself. This man, Monsieur Henry, was a professor of Natural Philosophy from Paris. The Philosophical Fireworks were an imitation of those shown at the Lyceum and invented by Diller. They were described as being made from "inflammable air, without smoke, smell, or detonation."[115] Apparently they were gas jets arranged in pattern and design, some revolving and some stationary. From a bladder, air was forced thru an ether saturated sponge. By turning the gas on and off at separate sets of holes movement and variation were produced. Green and rose seem to have been the only two colors used.[116] Such private enterprises, alone, were used to celebrate the Peace of 1802.[117]

The last of the eighteenth and the first half of the nineteenth century saw the development of the Pleasure Gardens. These provided a general form of evening entertainment, giving the public something similar to the cinema of today. Most of the gardens served more or less elaborate meals and liquid refreshments of many kinds. They showed displays of everything from horsemanship to painting. Many of the gardens included fireworks as a regular feature and nothing was more generally enjoyed than this diversion. Nearly all the gardens used fireworks at least for special occasions.[118] Vauxhall and Ranelagh are the best remembered gardens, but neither of these was an early leader in using fireworks.

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[115] Ibid., p. 36.

[116] Ibid., pp. 36-37.

[117] Ibid., p. 39.

Ranelagh used them permanently from 1767 until they closed in 1805. After that these gardens were only opened for special occasions. On June first, 1812, by the authority of the Right Honorable the Lord Chamberlain, the gardens were opened in honor of His Majesty's birthday, with "a grand naval and military fete and a superb exhibition of fireworks."[119]

Vauxhall's first outstanding display was in 1798, over fifty years after the first use of fireworks in the less famous gardens. They did not become a permanent feature at Vauxhall until 1813. Then the displays continued until 1859 when the garden closed with a "Farewell Forever" in flame.[120] The Firework Temple at Vauxhall, shown in

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[118] *Ibid.*, p. 32.

[119] *Ibid.*, p. 33.

[120] *Loc. cit.*

Plate VII, page 155, gives an idea of the grandiose scale of some of the productions.

With such regular use of fireworks in the program of public entertainment, the displays became more and more ambitious and the rivalry very keen. Whenever there was an official display, as for the celebration of a peace, it had to be on a scale of unexampled lavishness.[121]

Following the Crimean War there was one of these rejoicings of hitherto unprecedented scale which was marked by four displays. They were held at Hyde Park, Green Park, Primrose Hill, and Victory Park. This arrangement was made to divide the crowd. Three of the programs were identical, but the one at Primrose Hill was mainly aerial.[122] Tyrell, in his _History of War with Russia_, tells most interestingly of the Green Park production.

> At the appointed signal there was a continuous discharge of maroons, accompanied by brilliant illuminations with white, green, and yellow fires. . . . Then for two hours followed every conceivable design of elegant and dazzling pyrotechnic art. Flights of rockets a hundred at a time; revolving wheels, sun star and golden streamers, and fiery serpents chasing each other through the air. Gerbs, Roman candles, tourbillions, shells and fixed pieces of the most fantastic designs and brilliant hues. The eyes were dazzled by the intensity of the light. . . . It was strange to believe that so fierce and ungovernable an element as fire could be rendered so delicately

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[121] _Ibid._, p. 39.

[122] _Ibid._, p. 43.

> obedient to the will of man. . . . The triumph, however, of the entertainment was reserved for the close of it. This was a tremendous bombardment, during which the air was constantly filled with flights of rockets. . . . As an introduction . . . there were five fixed pieces, all of complicated construction, the center being an enormous one which amid all its fantastic blazing and revolving, exhibited the words "God Save the Queen."
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> . . . Then rose up into the blackness, rapidly one after another six flights of rockets, comprising altogether no less than ten thousand of these beautiful and brilliant instruments. . . . It was a spectacle as man could not reasonably expect to witness more than once in a lifetime.[123]

The modern era of pyrotechnics. Claude Rugierri may be regarded as the last of the ancients. He appears to have been the first to introduce color on anything approaching modern lines and though he did not advance greatly, what he did was a marked advance in the art.[124] Actually it was the introduction of chlorate of potash as a color producer which marks the commencement of the modern epoch of pyrotechnic art.[125] It was around 1830 that the first efforts were made and in 1854 F. M. Chertier devoted almost an entire book to the subject of color.[126] This new element in design possibilities resulted in the rapid elimination of the useless additions still remaining in some of the displays.

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[123] Ibid., p. 46.

[124] Ibid., pp. 143-44.

[125] Loc. cit.

[126] Ibid., p. 147.

The art of firework making gradually improved, particularly through the work of those specialists who had the advantages of being guided by scientific knowledge. Today this knowledge is of great value because the pyrotechnist must be governed by the principles of chemistry in selecting materials and by the laws of mechanics in producing his remarkable effects. As in all cases, however, science is useless without the aid of practical experience and the manual dexterity acquired by the craftsman.[127]

Displays of the modern era. Fireworks continued in popularity during the nineteenth century. In France they were a national institution irrespective of the form of government in power. Louis Napoleon, like his uncle, was fond of fireworks. Perhaps he found it a good means of gaining popularity, so any public event was a good excuse for a pyrotechnic exhibition.[128] In England C. T. Brock was one of the most active men in the field. It was through him that displays were first shown in the Crystal Palace. He had considerable trouble in convincing the directors that "fireworks were not of an immoral tendency" for some of the gardens where they had been most popular had not been above reproach.[129]In 1865 the Crystal Palace agreed to give the fireworks a trial and they proved so successful that their use continued until 1910. The attendance at a revival in 1920 proved that public taste for fireworks was even then far from diminishing.[130]

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[127] Orme Mason, "Pyrotechny," The Encyclopedia Brittanica, 9th edition, X, 134.

[128] Brock, op. cit., p. 42.

In particular, a wheel display was very popular at the Crystal Palace. This was usually fired in a group of three, with the design varying in form, movement, and color from time to time. The "Thunderbolt" was another popular feature. It was a compound shell which contained one hundred four-ounce rockets.[131] Pictorial set pieces were introduced by Brock in 1875. For the exhibition of such things as a battle scene he could manage an area ninety feet high with a six hundred foot frontage. Sea battles were a favorite subject and by ingenious devices the most realistic spectacles could be produced. Guns would fire, shells would burst in all directions, and even gaping holes would appear in the sides of the vessels.[132] Boat wrecks and rescues, and natural castrophes such as the eruption of Vesuvius and the destruction of Pompeii were frequently presented. The reproduction of famous buildings was another favored subject. In 1879 portraits in fire were introduced and a bit of good theatre was included by having many of them fired electrically by the eminent originals from the Royal Box.[133]

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[129] Ibid., p. 47.

[130] Ibid., p. 48.

[131] Ibid., p. 108.

[132] Ibid., p. 48.

Transformation pictures were developed in 1887. The first successful one was the portrait of Lord Beaconsfield coming through primroses. The piece began by showing the floral design. After it had burned a while it became transformed into a portrait, the lines for which had been worked inconspicuously into those of the floral design and camouflaged by its colors. The portrait was white. Still more complicated were the puzzle transformation pictures, such as jungle scenes turning into animals. A favorite was the sequence of the four seasons. The effect was produced by using lances of varying compositions and differing lengths. This required exact manipulation and untiring supervision.[134]

C. T. Brock patented living fireworks in 1888. A performer was dressed in asbestos overalls plus a light wood framework on the side nearest the audience. The framework was set with lances outlining the particular character to be portrayed. The first subject to be tried was a boxing match and even today this is probably the most successful one produced. Other favorite scenes were cock-fights, cat-fights, sailor's hornpipes, trapeze artists, and snake charmers.[135] It was with these living fireworks that Brock introduced children's fireworks as part of the annual Crystal Palace display in 1890. The first one was a Jack in the Beanstalk picture and five years later he did the Village Blacksmith, with blacksmith, horse, forge, bellows, and all necessary properties.[136]

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[133] Ibid., p. 50.

[134] Ibid., pp.50-51.

A contemporary version of these living fireworks was given in New York in 1936 when:

> Veteran fireworks fans last summer shouted their delight at a new "set piece." Outlined against the sky . . . a ten foot hen flashed in flaming color, strutted awkwardly a few steps, sat down and laid a fiery egg; then the hen rose and a chick stepped from the egg. The process was repeated until the mother hen had laid three eggs and hatched three chickens. Four pyrotechnicians helped her lay the eggs: one, protected by a tin shield carried the "walking hen"; three carried the chicks. The glare hid the stage hands.[137]

Among the smaller variety of set pieces which were shown around the close of the nineteenth century there could easily be traced the history of locomotion during the years covered by the display--bicycles, motor cars, aeroplanes, hansom cabs, fire engines--and in 1895 the two best mechanical pieces of that time were fired. They were full size representations of the latest type of express engine, complete with exact details and working parts.[138]

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[135] Ibid., p. 51.

[136] Ibid., p. 52.

[137] "Burning Up $4,000,000 in the Skies," Literary Digest, 122:36, July 4, 1936.

Perhaps the greatest display ever fired was at the official celebration of the peace in Hyde Park in 1919. Something of its excellence can be seen in Plate IX, page 157. The shells set off varied from five and one half inches in diameter to sixteen inches. Rockets of one pound were fired in flights of a hundred. The finale was a flight of three thousand rockets and Roman candles containing two hundred charges apiece.[139]

For a good many years the average American's only thought of fireworks was for the fourth of July celebrations. For this, the greater the noise, the greater was the satisfaction. Lots of firecrackers, son-of-a-guns, torpedoes, sparklers, and a few golden fountains, pin wheels, and Roman candles for after dark, made the day. At the time of the Declaration of Independence, John Adams councelled his fellow revolutionists to celebrate their independence with "pomp, parades, bonfires, and illuminations."[140] Samuel

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[138] Brock, op. cit., p. 53.

[139] Ibid., p. 52.

[140] "Burning Up $4,000,000 in the Skies," op. cit., p. 36.

Adams told Congress that the day should be observed with the firing of cannon and rockets and much tumultuous expression generally.[141] During the Revolutionary War the fall of Vicksburg coincided with the national birthday and the South has since been loath to celebrate the Fourth of July with the rest of the nation.[142] Instead, they continue the ancient practice of fires on Christmas and for New Year's Day. In 1911 they used half again as many fireworks for their year end festivities as the North did for its Fourth, although the North's purchases represented a greater financial investment.[143] For the sesquicentennial exposition in Philadelphia in 1926 a pageant and fireworks were enacted before a curtain five hundred feet long. The nightly display included three hundred actors in costume and thirty fireworks operators. Such pyrotechnic tableaux as the Liberty Bell, Betsy Ross, and Uncle Sam's One Hundred Fiftieth Birthday Cake accompanied the spectacle.[144]

Gradually the American fireworks scene is changing. Each year there are fewer firecrackers and more fetes where experts "skilled in the intricacies of decorative effects, stage and direct the marvels which constitute today's pyrotechnic wonders."[145]

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[141] Davis, _op_. _cit_., p. 5.

[142] _The Christian Science Monitor_, June 29, 1940.

[143] Davis, _op_. _cit_., p. 12.

[144] Paul Paddock, "Staging Plays in Fireworks," _Popular Mechanics_, 46:86, July, 1936.

Today there are few peace pacts to celebrate, but the United States does not go without fireworks displays. At the Fiesta celebrating the opening of the Golden Gate and the Bay Bridges over the San Francisco Bay, a prominant feature was the fireworks displayed.[146] Excellent productions were shown during the Golden Gate International Exposition. At the New York's World Fair there were nightly displays on the Lagoon of Nations and on Fountain Lake. These were the design spectacles of Jean Labatut. Fire, fireworks, smoke, lights, water, and music were fused into immense abstractions, defined by searchlights and the open sky. Further to hold the attention of the pleasure bent crowds, Mr. Labatut titled his spectacles "The Spirit of George Washington," "The Story of Three Flowers," "The Garden of Eden," "From Clay to Steel," and other similarly descriptive titles.[147]

On a smaller scale, beach resorts offer displays for their summer occupants. For example, Riis Park in New York gave a show every Friday during the season in 1937. At

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[145] "Spectacular Fireworks Turn Night into Beauty," Popular Mechanics, 70:10, July, 1938.

[146] The Oakland Shopping News, November 9, 1936; also Popular Mechanics, op. cit., 1938, pp. 15-16.

[147] "Symphonies in Sight and Sound," Magazine of Art, 32:290, May, 1939.

8:45 p.m. a parachute shell released a reproduction of an American flag as a signal that the program would begin in fifteen minutes. Hanging chains of fire, aerial fireworks, and set pieces then were displayed.[148] Occasionally, as well, private individuals finish off an evening's entertainment with such diversions, to the considerable pleasure of their guests.[149]

III. ARTIFICES NOW IN USE

Modern effects, especially color, may be said to date from the close of the nineteenth century when chlorate of potash and sulphur were introduced as color makers. Colors so obtained are unapproached by any other means but it is a dangerous admixture. Its use precipitated numerous laws of operation and building construction for the protection of workers.[150]

There is an increasing popularity for aerial shows. This is quite understandable after seeing shells travel a thousand feet in the air before exploding into bursts of colored stars and streamers.[151] On the other hand, the public never seems to tire of set pieces, either. One reason may be that there are never two set pieces alike. Another may be that the medium is readily adapted to current events. Designs are put on wooden frames, outlining the pattern with lances on strips of rattan. These lances can be measured to burn from a few seconds to more than two minutes, producing intricate and beautiful decorations which exemplify the great advances made in exhibitional pyrotechnics.[152] The modern designer of piece pyrotechnic has a great advantage over the earlier producers, for he has an infinitely larger range of material with which to work. Often he can get much enhanced results and more varied effects with less cases than the earlier man required. Many early attempts to produce a lavish show of fire ended in a display of confusion.[153]

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[148] New York Times, August 6, 1937.

[149] "Life Goes to a Party," Life, 7:70, August 7, 1939.

[150] Brock, op. cit., p. 74.

[151] "Painting with Fire," Popular Mechanics, 64:124A, July, 1935.

The Japanese, with the characteristic of that race for careful and exact manual work, have developed aerial fireworks to remarkable perfection. Although the effects obtained are extraordinary, they do not compare in color or brilliance with those of the western world.[154]

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[152] Popular Mechanics, op. cit., 1938, pp. 13-14.

[153] Brock, op. cit., p. 132.

[154] Ibid., p. 7; also an interesting description of the modern Chinese fireworks is to be found in the letter from B. A. Liu, p. 139.

In the United States it is only within the last sixty years that American inventors have begun to dabble in "painting pictures across the heavens with gunpowder."[155] A background of colored fire is occasionally added to enhance the effect of the set pieces. This background is made by firing pads of excelsior, saturated with alcohol or coal oil, which have been sprinkled with minerals giving the desired colors when burned.[156] At other times colored electric lights are played on puffs or clouds of smoke to give variety and heightened effects.[157]

Color effects. The principles of producing colored effects in fireworks are basically two. The first is to get a mixture that will burn at a reasonable speed while generating an intense heat. The second is to add to this material the salts of such elements as have predominant lines of the desired colors in their spectrum.[158] In the main, color effects are made by using strontium salt for red, barium nitrate for green, sodium oxalate for yellow, anc copper and mercury salts for blue.[159]

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[155] "Painting the Sky with Powder," Popular Mechanics, 42:19, July, 1924.

[156] "Spectacular Fireworks Turn Night into Beauty," op. cit., p. 14.

[157] Mr. Fowler at Otto K. Olson's mentioned this in an interview.

[158] George W. Weingart, Dictionary and Manual of Pyrotechnics (New Orleans, Louisiana: n. n., 1937), p. 5.

Until a few years ago powdered magnesium was added to the other ingredients to produce bright effects with a dazzling white fire. The price was excessive and aluminum has now been substituted. Zinc powder is used in the making of Electric Spreader Stars. The effect is very interesting for the materials break up while burning into numerous small bluish-green particles which, because of the considerable force of propulsion, appear much like electric discharges. Picric acid is also added to colors in small quantities. It deepens the color and increased the brilliancy, without causing much increase in the rate of burning.[160]

Rockets. The word rocket is of Italian origin. It is based on the resemblance of the rocket on the end of its stick to the piece of wood used in the middle ages to cover the point of the lance during mimic combat. The lance was called a "rockette" meaning diminutive distaff.[161]

The rocket is the most important unit in the art of pyrotechny.[162] Its case is cylindrical and constructed so that fire issues from it in a stream. A tapering hole runs almost the entire length of the composition providing a maximum burning surface, while a small orifice restricts the escape of fire and gas, resulting in a powerful jet of fire and a maximum force for putting the rocket in motion.[163] Rockets, like most fireworks, contain saltpetre, sulphur, and charcoal in varying proportions. A higher proportion of charcoal gives a larger tail, desirable in signal and display rockets. In 1635 John Bates recommended the addition of "yron scales" to further increase the effect of the tail.[164] Today iron filings are added.

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[159] Arthur J. Hale, "Pyrotechnics," Modern Chemistry Pure and Applied (London: Vurtue and Company, Ltd., 1921), V, 97.

[160] Weingart, op. cit., pp. 20-21.

[161] Brock, op. cit., p. 92.

The body of the rocket is the propellant and the head contains the garnitures.[165] This is sometimes called the pot. It is in the pot that the materials are put which cause the cluster of stars, the colored rain, or other bursts commonly expelled when the rocket reaches its greatest altitude.[166] The garnitures with which rockets are equipped have endless variety. They may be combined so that a number are united in one flight, simultaneously or in a sequence, forming a distinctive display.[167]

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[162] *Ibid.*, p. 92.

[163] *Ibid.*, p. 93.

[164] *Ibid.*, pp. 95-96.

[165] Hale, *loc. cit.*

[166] *The New International Encyclopedia*, *op. cit.*, pp. 405-6.

Although the best known form of rocket is the sky rocket, there is also the ground rocket or fire jet. Such a rocket is loaded solidly so that it operated without leaving the place where it is fastened. This was probably the source of the first fountain type of firework. It was called a gerb. The name was derived from a French word meaning "sheaf of corn."[168] Especially when Chinese fire is employed, these jets produce excellent decorative effects.[169] Squibs and golden rain are smaller varieties of the fire jet used most frequently in display work for the fringe on a frame or lattice in a set piece.

Simple fireworks, mine class. The parent of the mine class is the shell or bomb. It was originally called an air balloon and Rugierri claimed that his father released the first one in 1786.[170] However, there are acceptable descriptions of such artifices as early as 1625. Frezier wrote of them in 1747. In describing a fireworks shell he said that the purpose of the bomb was amusement. It went vertically into the air and threw its garnitures at the point of highest elevation. While going up in the air it only showed a small stream of fire which was multiplied suddenly into a great number at the moment of highest elevation. Frazer thought this to be the principal beauty of the bomb.[171]

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[167] Faber, op. cit., p. 175.

[168] Brock, op. cit., pp. 98-99.

[169] Faber, op. cit., p. 133.

[170] Brock, op. cit., p. 103.

In the last few years the bomb has been replacing rockets at shows. The bomb, when it bursts, scatters into a million harmless bits of paper, while the long, heavy, wooden guide sticks of rockets have been known to fall among the crowds. In the hands of experts bombs are safer and easier to handle than rockets and they can be better packed than rockets to create colored fire patterns in the sky.[172] Bombs and grenades are constructed to stand the shock of being projected from a mortar. They are filled in such a way that the collection of fireworks kindles when the required height has been reached.[173] Some are hurled as much as a thousand feet. When they burst they scatter their carefully set contents over the heavens, taking up as much as a full acre of aerial space. Bombs can be packed for multiple bursts, to as great a number as six. Each explosion can release different patterns--weeping willows, pompoms, feather and spray, or star chains.[174]

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[171] *Ibid.*, pp. 103-5.

[172] "Spectacular Fireworks Turn Night into Beauty," *op. cit.*, p. 11.

[173] Faber, *op. cit.*, p. 177.

The modern variety of bombs and shells are almost infinite. One variation is the comet which is a small shell with an exaggerated fuse of brilliant fire which leaves a heavy tail during the flight. These comets are often fired from opposite sides of the display grounds, in a rapid succession, which produces an aerial arch so spaced that the comets open just after passing each other. A Jack-in-the-Box is composed of a fountain case which fires in the usual way, but when finished ignites a lifting charge blowing up a collection of contained fireworks. A variation of this is called Devil-among-the-Tailors. It is the same device surrounded by Roman candles.[175]

Roman candles, available evidence seems to indicate, originated in England. In 1635 Babington called them "a trunk of fire which shall cast forth divers fire balls at the time intended,"[176] and in 1765 a contemporary writer described Roman candles exactly as known today, calling them Fire Pumps.[177] By 1818 they had acquired the name Roman candle for as such they were advertised in an announcement of a coming exhibit.[178] Roman candles are packed with repetitions of fuse, dark fire, stars, and a blowing charge. The fuse burns in a fountain effect and ignites the dark fire which lights the star. This flashes around and fires the blowing charge which propels the star from the case. At the same time the next layer of fuse is ignited and the effect is repeated.[179]

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[174] "Spectacular Fireworks Turn Night into Beauty," op. cit., pp. 12-13.

[175] Brock, op. cit., pp. 109-11.

[176] Ibid., pp. 111-12.

[177] Ibid., pp. 112-13.

Simple fireworks, Saxon and lance class. The Saxon, or Chinese flyer as it is also called, is a revolving artifice. It is a single case which is made to rotate in the plane of its own axis by jets of fire projecting through a hole at right angles to the axis. Saxons revolve about a nail driven through the case to a post or other support. Frequently in display work a small case with a color charge is attached to the side of the case producing a ring of color within the fire of the Saxon. A tourbillion is a further development of a Saxon, so arranged that when the revolution of the case has reached sufficient rapidity the piece is projected into the air.[180]

In the lance class is the pin or Catherine wheel.

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[178] Ibid., pp. 112-13.

[179] Ibid., p. 114.

[180] Ibid., p. 117.

This is a simple rotating firework which burns down as the composition is consumed. The revolutions are determined by the pressure of the gas as the compositions burn.[181] Until the beginning of the nineteenth century pyrotechnicians failed to realize the possibility of lance work. Perhaps this was due to the fewness of colors available.[182] Lances are of great value in display work, especially on set pieces. One battle set used at the Crystal Palace consumed thirty thousand lances in a single display.[183] An outline drawing of a subject is first made, eliminating all the unnecessary lines. Then the drawing is cross ruled on a scale that will make each square represent one foot of the required size. Frames are then laid on the drawing room floor, the drawing transferred, and lances attached about every four inches.[184] Lance artifices are also favorites for the garden type of display, especially starlight and feathers, squibs, and golden rain. Although they are pretty, they are not distinguishable at a distance.[185]

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[181] _Ibid_., p. 118.

[182] _Ibid_., p. 128.

[183] _Ibid_., p. 118.

[184] _Ibid_., p. 128.

[185] _Ibid_., p. 119.

Compound fireworks. Compound fireworks are composed of a number of simple fireworks fixed to a framework or device so as to produce a more elaborate effect. Probably the earliest ones made were sky rockets tied around a wheel. The pressure of firing would cause the wheel to rotate.[186] A compound shell is a bomb filled with such fireworks as Roman candles, tourbillions, small shells, or rockets. Brock believes that the shell filled with rockets gives "the most dramatic aerial effect yet devised."[187]

Mosaics are designs formed by arranging gerbs on a framework so that their fire forms symetrical, geometric patterns. This effect may be heightened by Saxons in suitable positions. When lattice poles are provided with cleats the cases can be arranged so that the firing crosses, forming a lattice of sparks.[188] Examples of this sort of artifice can be seen in Plate VIII, page 156.

Vertical wheels are often elaborate with color cases, one type being called the rainbow wheel. Variation is readily obtained by arranging different shapes and numbers of wheels in one piece. A very effective compact piece is made of horizontal wheels with varying directions of fire when revolving.[189] Revolving fountains are also a spectacular arrangement of compound fireworks.[190]

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[186] Ibid., p. 121.

[187] Ibid., p. 108.

[188] Ibid., p. 127.

Water effects. It is worthy of note that even in the early years of pyrotechny, displayers seemed to realize the value of water in enhancing the effect of fireworks. As early as 1613 a reviewer wrote: "Many artificial concussions of Fire-Workes were upon the Thames performed."[191]

Fires for water display are basically the same as displays discharged on the ground or aloft. The one precaution is to arrange the materials in such a way that whether diving or floating, the case will not become saturated before it has taken fire.[192] The divers or plungeons are usually gerbs charged in such a way that jerky burning is produced. The recoil of each puff drives the gerb beneath the water, but the jet of fire is sufficient to prevent water entering the case while it is submerged.[193] Another distinct water variety is the skimmer or stickless rocket. The rocket has an empty cap fastened at an angle to the main case. When it is fired it skims the water and occasionally dives under in its erratic course. For a safe display the skimmer needs considerable area.[194]

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[189] Ibid., pp. 131-33.

[190] Ibid., p. 134.

[191] Ibid., p. 24.

[192] Faber, op. cit., p. 143.

[193] Brock, op. cit., p. 101.

Daylight effects. The use of daylight effects is essentially a novelty, developed in the last few years. Most of the daylight artifices come from Japan where they were originated. Instead of pyrotechnic effects, when the projectile reaches its maximum altitude, a light framework coverec with sheer silken fabric is thrown out and floats in the air suspended by parachutes. The framework often appears to be the grotesque form of an object such as an animal colored in accordance with the desired design. Other effects are colored clouds, showers of streamers, confetti, and toys.[195] In summary Faber says:

> In the present development of pyrotechnics there is almost no limit to be placed on the ornate forms of spectacular entertainment. The principles that have already been described are capable of infinite modification and variation. Almost any desired effect may be achieved by a suitable mingling of pyrotechnic material and devices.[196]

IV. NON-LUXURY FIREWORKS

Producers solidly point out that their business rests on two fairly sturdy supports: patriotism, and the perennial demand for spectacular entertainment.[197] Nevertheless, about one fourth of all fireworks sold in the United States goes for non-luxury and military used. Lifeboats carry them, by government regulation, for identification and distress signals. Flares are needed by the newsreel cameramen. The railroads require fusees and track torpedoes. Fairly recent is the use by construction engineers of smokepots to explore ventilation defects.[198]

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[194] *Ibid*., p. 101.

[195] Faber, *op. cit*., p. 180; also Brock, *op. cit*., p. 101.

[196] Faber, *ibid*., p. 179.

In non-luxury fireworks as well as in the entertainment variety, the rocket still maintains its supremacy. As late as 1815 a British rocket brigade caused considerable havoc among the French when they attacked them with thirty inch long incendiary rockets that gushed fire as they struck. Shortly after that the rocket gave way to the cannon as an engine of war.[199] The rocket light ball is the principal one of value today. The light ball which is discharged is suspended by a parachute which will give a permanent brilliance for at least five minutes. This is valuable for observing an enemy or for aid in performing night rescues. An advantage lies in the slight weight and bulk of the rocket.[200] A succoring rocket is another variety. This carries a cord aloft and is of use in sending messages, making a contact with land or a floating mooring, or even saving the life of a man overboard.[201] The enthusiasm felt one hundred years ago for rockets as a war weapon has been abandoned since the extensive development of guns in warfare, but the values for signaling and illumination are still considerable.

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[197] "Burning Up $4,000,000 in the Skies," op. cit., pp. 36-37.

[198] Editorial, Fortune, 16:19, July, 1937.

[199] "Burning Up $4,000,000 in the Skies," op. cit., p. 37.

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[200] Faber, *op. cit.*, pp. 62, 66.

[201] *Ibid.*, p. 71.

CHAPTER IV

ART SIGNIFICANCE OF PYROTECHNICS

When the public is asked if it considers a fireworks show beautiful the invariable response is in the affirmative. In spite of the simple recognition that a pyrotechnical display provides a satisfactory experience of beauty there are no records of fire work displays in the history of fine art or folk art. Perhaps this is because the inevitable transciency of the medium never permitted the preserving of any actual examples. Until comparatively recent times all evidences of pyrotechnic progress had to be made by static visual or literary recordings. Perhaps because pyrotechnics primarily have emotional value, instead of use value, reviewers of art overlooked them. In spite of their popularity at festivals and celebration, there was no carry-over into everyday life. Technical limitations prevented the common people from experimenting creatively with the medium, as they could with music and the dance. The infrequency of the use of pyrotechnics no doubt contributed to their being practically overlooked by historians and completely ignored by art critics.

I. CRITERIA FOR AESTHETIC VALUES

Throughout the literature of aesthetics there seem to be numerous approaches to an analysis of the meaning of art principles, and of the presence of aesthetic content in the arts. Raymond Stites feels that the resulting confusion arises from the haphazard application of criticism which fails to recognize the existence and separate function of the several aspects of art.[1] The writer prefers his simple and convincing analysis of the qualities identifying aesthetics to that of any other author, for use in this paper.[2] His outline will be used as the basis for analyzing the possible art content of pyrotechnics.

Varying proportional combinations of three factors are responsible for arousing our emotional responses, the source of aesthetic reactions. These qualities are the (1) use, (2) association, and (3) formal values. Use connects art with our daily living; association explains our more personal feelings; and the formal values usually are the methods of expression which bind the use and associational values together.[3] Though some would consider the formal value the unique element in a work of art, it cannot be considered the sole value. If it were the only true value, the highest form of art would be that in which the use and associational value play the least part. Such a premise is unfair especially to architects and potters.[4]

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[1] Raymond S. Stites, The Arts and Man (New York: McGraw-Hill Book Company, Inc., 1940), p. 28.

[2] Ibid., pp. 3-79, 828-33.

[3] Ibid., pp. 6-8.

Our aesthetic experiences cannot exist singly because other attitudes intervene. For example, the ever changing, ever curvilinear line of the flame is aesthetically stimulating. The Greeks called it the Praxitelean curve of beauty.[5] Yet, the aesthetic experience of enjoying a flame as a thrilling spectacle may be modified if the fire assumes destructive proportions.[6] Considerations of the grief and loss caused, in this instance, are the attitudes which intervene.

It is possible for individuals to receive different stimuli from the same situation. Differing physiological structure, such as variations in the eye,[7] are responsible for some deviations. Previous experiences are bound to influence judgment. Much of what is considered art quality is a subjective emotional response of the individual. The values peculiar to each individual are projected unconsciously upon the object.[8] But, regardless of the fact that feelings and emotions produced vary, the thrill of the perfect is an experience common to many.[9] The source of stimulation seems reasonably accounted for in use, association, and formal values.

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[4] _Ibid_., p. 8.

[5] _Ibid_., p. 828.

[6] Margaret N. H'Doubler, _Dance_ (New York: F. S. Crofts and Company, 1940), p. 113.

[7] Milton H. Bird, _A Study in Aesthetics_ (Cambridge, Mass.: Harvard University Press, 1932), p. 11.

Two major divisions of the arts can be made: spatial and temporal. Such space arts as sculpture, painting, architecture, pottery, and weaving, achieve unity through manipulation of material in space. The temporal arts of music, poetry, dance, and drama achieve unity through the manipulation of sound or moving forms over a duration of time.[10]

The same three goals lie behind both these forms of art expression: (1) the beautiful, an expression of static qualities, (2) the energetic, or dynamic mood, and (3) the sublime or awe inspiring stimulus. The greatest works of art contain a synthesis of these qualities, the predominant goal depending on which one seems most important to the personality experiencing the work of art.[11]

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[8] Thomas Munro, Scientific Method in Aesthetics (New York: Norton and Company, Inc., 1928), p. 19.

[9] H'Doubler, op. cit., p. 115.

[10] Stites, op. cit., pp. 24-26.

[11] Ibid., pp. 11-12.

II. COMPARATIVE DEVELOPMENT OF PRIMITIVE ART AND FIREWORKS

A parallel seems to exist between the evolution of pyrotechnics and the evolution of the whole field of primitive art.

Although many are not in unanimous agreement with him, William Worringer believes that all primitive art arose from the emotion of fear.[12] Self preservation was a keynote. Painting of the body, for instance, may have been considered some form of protection. George Grant MacCurdy takes the view that origins of art were magical and religious. Inventory of the early examples of art show that most of the animals depicted were those difficult to capture and those beasts of prey feared by the earliest man. Probably such recordings when made, had magical implications.[13] De Morgan holds that the two origins of art were delight in technical skill and interest in imaginative conception.[14] Bilateral symmetry probably gave man his first aesthetic experience in handicraft. For example, the arrow which he made, which we today call the most beautiful, was, for him, the most efficient because his primary concern was self preservation and defense.[15] He received a secondary delight from creating a useful object, leading somewhat to an aesthetic impulse.

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[12] Ibid., p. 41.

[13] Ibid., p. 49.

[14] Ibid., p. 49.

As life shifted from one of nomadic hunting to the agricultural life, there was a trend from naturalism (physioplastic) toward abstraction and symbolism (ideoplastic). Within the priestcraft there was an attempt to focus imagination in a few abstract symbols, for the recognition of the powers of sun, wind, fire, and rain could only be expressed symbolically.[16] Following along, step by step, was the fact that design expression and technique necessarily grew together, influencing each other. The path of evolution was stimulated by fear, magic, religion, and growth of technical skill.

In the chapter on the evolution of pyrotechny much the same story has been traced. At the outset fire was important to daily life. Its possession was a protection from animals and the elements; its loss caused both discomfort and danger. Here was the fear element. The peculiar qualities of fire stimulated primitive curiosity and its occurrence as a natural phenomenon gave it a prestige soon to fall at least partially under the control of the sorcerers and priests. The rocket is said to have been devised by priests to represent the living spirit of flame mounting to heaven as a messenger to the fire god.[17] Here were the elements of magic and religion. Out of bonfires the priests developed more technical artifices by the aid of minerals and salts at hand. Here was the influence of technical skill.

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[15] Ibid., p. 41.

[16] Ibid., p. 69.

Impetus was given the symbolic development of pyrotechnics as agricultural mode of life increased the awareness of the powers of nature. Symbolism was the only possible means of expression. The feeling of relationship between fire and the sky may have come from lightning, sunshine, falling stars, volcanic explosions, or a combination of these factors. That it was well rooted and of considerable longevity is seen in the fact that the Greeks gave their highest honors to Minerva, queen of the air, who was also the queen of fire. She might well have been considered the patron diety of pyrotechny.[18]

The delaying element in the progress of pyrotechny was the lack of technique. The tools necessary for advances in design were hidden deep in the mysteries of nature.

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[17] Henry B. Faber, Military Pyrotechnics (Washington: United States Government Printing Office, 1919), I, 57.

[18] Ibid., p. 20.

Development was dormant throughout the Middle Ages when man was contemplating the other worldliness of the future. It only began to stir again when the romantic movement sent man out on the Crusades. From the East he returned with Greek fire. Assisted by this substance the Western world invented gunpowder. Then with increased tools and technique the art of pyrotechny acquired greater splendor, new form, and more significant expression.

III. QUALITIES PECULIAR TO PYROTECHNICS

Pyrotechnic displays, like drama and motion pictures, combine the elements of both spatial and temporal arts. As in the dance, a fireworks production is an expression of movements in relation to space; but, unlike the dance, there can be no personal interpretation filtered through the performance. All the action has been predisposed; once an artifice has begun firing no human element is present. Whereas the dance can be indulged in by amateurs, a creative fireworks production requires professional training. In dance, music, or poetry the total effect is built up event by event in a progression from which there is no backtracking. There is a need to grasp each significant line or movement at the instant it is presented. The same emotional tension is felt at a fireworks display, not only because the display must be enjoyed at the moment, but also because of the impossibility of a repeat performance. The closest the observer ever can come to a review performance of a fireworks display is through photography. In discussing a photograph of fireworks, the Illustrated London News states:

> The rapidly changing effects of fireworks forms a subject of which only a general impression could be obtained with brush or pencil. Photography however . . . can seize every phase of the display at any given moment.[19]

Nevertheless, unless color movies are taken, much of the spirit of fireworks is lost. The very fact that they have been reduced in scale destroys some of the awe-inspiring quality. Still photography minimizes the energetic element, and black and white photography cannot present the dramatic color of pyrotechny.

All temporal arts exist primarily in a period of time rather than space. In music and poetry the appeal is to the ear in order of time; in the dance and fireworks the appeal is to the eye in the order of both space and time.

Pyrotechny has the peculiar quality of being designed in the round; but, because of its transparency, appears as a flat pattern. Symmetry and radiation, elements peculiar to space arts,[20] are to be found in fireworks. Rhythm, an element of the temporal group is also present. However, the rhythm in fireworks is more a part of the individual piece than of the display as a whole. Visual harmony really establishes the feeling of unity. Differing from all the other space arts, pyrotechnics have no space restrictions except the visual field. The borders of the composition expand and contract with the flow of the artifices.

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[19] The Illustrated London News, September 19, 1931.

[20] Stites, op. cit., pp. 24-25.

Because of the numerous stimuli offered, an element of excitement characterizes fireworks displays. One feels the impatience of anticipation, the disquiet of suspense, the awe engendered by gigantic proportions, and the drama of extreme contrasts. The observer is gripped with a feeling of intensity not only because of the intense quality of the luminous brilliancy in the display, but also because of the instantaneousness and brevity of the record. The requirements of attention are so intense that Henry Pain, a prominant authority on displays, made an investigation to determine the most effective time span for maximum interest. He found that more than forty-five minutes destroyed the favorable results at a display. The brain seems unable to record impressions of brilliant pyrotechny beyond that period.[21]

The quintessence of fireworks displays, with all their inimitable qualities, seems caught in the following quotation.

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[21] Davis Hartley, "Siss! Boom!! Ah-h-h!!!" Everybody's Magazine, 25:12, July, 1911.

> More rockets! There are lovely ones that lean down in the sky like great spider lilies, with long out-curving petals of soft light, and at the end of each petal a sudden drop of pure green fire, as it were dew. But some strange hand of evenescense brushes the blossom away, and it is gone, leaving the next rocket to burst and show all the smoke threads stretching in the sky, the ghost of the gone lily.[22]

IV. POSSIBLE AESTHETICS OF PYROTECHNY

All art is based on nature and each age of man's culture has attributed new meaning to old forms. Use and associational values give rise to the need of expression, and result in the creation of an art object. The formal principles of art structure, before centuries of mankind's manipulation weighted them down with symbolic meaning, first appeared in nature.[23] Of fireworks Brock remarks:

> Pyrotechny is possibly the only art which can compete with nature: anyone who has seen a first-class fireworks display will admit that for impressive grandeur, colour effects, and contrast of light and shade, pyrotechnics is unapproached.[24]

Similarity to general aesthetic values. The writer believes that pyrotechnics show the same basic elements of art structure that other works of art demonstrate.

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[22] D. H. Lawrence, "Fireworks," Forum, 77:653, May, 1927.

[23] Stites, *op. cit.*, p. 23.

[24] A. St. H. Brock, *Pyrotechnics: The History and Art of Fireworks Making* (London: Daniel O'Connor, 1922), Preface xiii.

Formal principles of art. In defining formal values Stites contends that art is a striving to capture the living essence of the growing changeable spirit into a permanent form. The two great aspects of being, time and space, give rise to the two forms of artistic expression, temporal and spatial.[25] Pyrotechny is a peculiar fusion of time and space art, demonstrating the temporal aspects of movement and action, but through a visual medium. Although fireworks have substance, they are characterized by extreme transciency.

Symmetry and radiation are principles found only in space arts.[26] In a wood block of an ancient pyrotechnic device, reproduced in Plate I, page 149, the successful use of these principles can be seen. Both the star and the flower-like medallion, above the horse and rider carrying the fireworks, are symmetrical in design. The separate parts of the medallion demonstrate radiation, as well. The entire device, as observed from the position recorded, shows a symmetrical composition. A third formal principle can be noted in the positive feeling of balance within the whole. The abundant plumes of flame spurting from the massive part of the horse's body form a substantial base for the more dynamic and scintillating patterns above.

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[25] Stites, op. cit., pp. 23-24.

[26] Ibid., p. 24.

Emphasis is the principle which prevents monotony resulting from too mechanical balance and symmetry.[27] In pyrotechnics emphasis is as much a question of physical force as it is a problem of size, color, or location of units of design within the composition. The vigorousness and power expressed at the time of firing delineates areas of emphasis. These can vary with the progression of the display or remain constant.

Rhythm is a quality more dominant in temporal art than in spatial art. It is achieved through the manipulation of sound or moving forms over a duration of time and is another outstanding quality to be found in good pyrotechnical displays. Plate V, page 153, picturing fireworks on the Thames, June 17, 1688, shows an excellent example. The surge of each square fire fountain, as the successive artifices rise and drop their garnitures, would, in action, produce a vital, stirring rhythm. The effect is heightened by the repetitive line scheme within and between the units, and by the contrasting counter rhythms of the low burning fire-pots.

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[27] Ibid., p. 25.

The final principle of harmony arises from an interrelationship of the previously mentioned factors, symmetry, radiation, balance, and rhythm. The fusion produces a pleasurable sensation of satisfaction. However, this feeling of harmony of the formal principles is invariably tied up with use and associational values.

Formal elements of design. Out of the formal elements of art, the structure of man's art expressions are formed. In their simplest forms, line design, color, and pattern appear in nature.[28] They may be found in a more complicated arrangement in pyrotechnics.

Dynamic power is expressed in lines of growth, as in flowers and grasses. This upward movement, expansion with curvilinear contours, is probably the dominant line movement in aerial fireworks. Each breathless sequence creates an irresistible line pattern. For fireworks, as for all other forms of art, the earth provides the necessary pigments. The development of color technique in pyrotechny hinged on scientific discoveries. Probably the static art which pyrotechny closest resembles from the standpoint of color is night advertising. Colors from canvasses are often said to glow, but color visible because light falls upon a surface can never begin to have the luminous brilliance found in colors having light passing through them. When such colors have the foil of impenetrable night for a background they reach the height of their intensity. The observer of a good pyrotechnic display often feels that he has witnessed something at once ephemeral and architechtonic. He seems to have witnessed tremendous structural masses and before he is finished with examining them, they are gone. The strong contrasts of light and dark excite after images before the retina of the eye and further emphasize the mystic splendor.

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[28] *Ibid.*, p. 30.

Patterns, which are to be considered arrangements of the elements of line, shape, and color, also were first to be seen in nature. Man adapted many of these natural patterns to express his artistic ideas.[29] This pictorial element occurs quite frequently in fireworks. The photograph of the display at Hyde Park, in 1919, reproduced on page 157, Plate IX, shows the use of repetitional linear pattern, all-over pattern, and unit motif. The festoons of light balls to be seen in the center right are linear. To the right of this the free floating scrolls form an all-over design, and the fountain-like surges produce the effect of single motif units against a given space. Compound fireworks of geometric nature on set pieces, as shown in Plate VIII, page 156, offer even more specific examples of organized pictorial design.

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[29] _Ibid._, p. 31.

Use values in pyrotechnics. Stites points out that the use value of such compositions as Beethoven's *Fifth Symphony* is not necessarily obvious. However, the historical evolution of some of the rhythms echo a use value from the primitive ages of magic and elemental religion.[30] Such use value might be spiritual uplift, devotion, reverence, help in love-making, or in other emotional realms. Some of the use values of pyrotechnics are similarly rooted in the past. The ancient use values degenerated when the people were no longer mystified by the explosive art. The old artifices were still used, but the principle emotion aroused was that of pleasure. This use value was obvious throughout the later evolution of fireworks. Actually pyrotechnics were called joy fires in France. They were used on many occasions for jubilation, such as births, marriages, feast days, coronations, victories, and peace pacts. Perhaps this exaggerated emphasis of the joy element accounts for the fact that none of the displays were ever of sufficient inspirational character to spur people on to great activity. The very feeling of enjoyment makes people hesitate to take hasty action.[31] The optimist always likes to remain on the surface of things, never being inclined to probe the depths.[32]

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[30] *Ibid*., p. 6.

In representational art much of the pleasurable element is created by the recognition of familiar objects. In non-representational art the effect is dependent on the stimulation of the imagination.[33] Pyrotechny is often a mixture of both forms of art. Set pieces most frequently are representational and almost all aerial fireworks stimulate the imagination with abstractions. The pleasure gardens of Europe in the eighteenth and nineteenth centuries recognized this pleasure element when they incorporated fireworks shows into their program of events, and in 1940 the Christian Science Monitor reports:

> Fireworks still are recognized as a method of release from the humdrum of the workaday world. Even fireworks put on by the municipalities . . . are another form of art, expressions in color and flame and brilliance with a distinct thought behind the whole . . . comparable to that of the art gallery. . . .[34]

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[31] Ibid., p. 29.

[32] Oscar Hagen, Art Epochs and Their Leaders (New York: Charles Scribner's Sons, 1927), p. 31.

[33] Stites, op. cit., p. 16.

[34] The Christian Science Monitor, June 29, 1940.

In general it is safe to say that the mind is not conscious of the reason for the effect art has upon it, but only of the agreeable glow produced.

Associational values in pyrotechnics. The associational values may be either of the variety which edifies or enlightens the spectator or which soothes or stimulates him. Often the associative linkage is unconscious.[35] For example, in trying to analyze people's delight in the quick flight of birds, it appears to be the recovery from the headlong dashes which produces within the observer the sense of exhilaration. Perhaps this sensation can be traced to the infant's first emotion, fear of falling.[36] This may also account for much of the appeal of fireworks. The artifice rushes upward, bursts in glorious exaltation, and expires at its climax, apparently defying all laws of gravity.

Probably beauty is the most universal quality found in associational values of an art work. Ruskin says that which gives pleasure by the mere contemplation of its outward qualities without any direct exertion of the intellect is to some degree beautiful.[37] H'Doubler holds that all things seem beautiful when they have a value for the observer. This value may not even be the one the creator intended, but still, value may be received by some other sequence of associations.[38] Some such unintended associations can be seen in Faber's reaction to rockets.

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[35] Stites, op. cit., p. 29.

[36] Merle Armitage, Martha-Graham (U.S.A., Merle Armitage, 1937), p. 3.

[37] John Ruskin, Modern Painters (New York: John Wiley and Sons, 1873), Vol. I, Part I, p. 26.

> The rocket had it been known to classical Greece, might have been interpreted in her (Minerva's) behalf, as brave to dare the unknown dark, to mount with all energy until its very life was at an end, and with its last breath, to set on fire that burden which it has carried aloft, in order that, even after its own passing, a new glory should be spread in the heavens.[39]

In contrast, the Japanese associations with fireworks can be seen in their name for them which means "flowery fire." Just as they are fond of cherry blossoms whose beauty is ephemeral, they have a passion for the momentary display of fireworks on summer evenings. Fireworks may even reflect their characteristic shortness of temper, for the Japanese have an expression "like fireworks on a summer night" which signifies hectic, but short lived, enthusiasm.[40]

The beauty in pyrotechnics is not a quality which can be experienced by touch, nor can it be cherished privately. The pleasure derived is comparable to the fragrance of perfume, the charm lying in the first breath and the surprise of the encounter.[41] Deacon contends that half the joy of beauty is the discovery of it.[42]

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[38] H'Doubler, op. cit., p. 112.

[39] Faber, op. cit., p. 20.

[40] Travel in Japan, June, 1940, pp. 1-7.

As Mrs. Miniver so ably explained, the attraction of fireworks

> . . . was more complex than that of any other form of art. They had pattern and sequence, colour and sound, brilliance and mobility; they had suspense, surprise, and a faint hint of danger; above all they had the supreme quality of transience, which puts the keenest edge on beauty and makes it touch some spring in the heart which enduring excellences cannot reach.[43]

The most obvious associational values have been covered in the chapter on the evolution of pyrotechny. Stories of Greek mythology, national narratives, allegories for the instruction of the people, the history of locomotion, reproductions of famous buildings, all were used as subject material for displays. Gradually the shows became more and more marked for their beauty as well as for their ingenuity.[44] Transformation pictures provide great opportunity for the flow of associative ideas, piquing the imagination, creating suspense, engendering surprise, and providing satisfactions. It seems to be part of our nature to cling to familiar things and at the same time to yearn for the strange.[45] It if from the combination of these two characteristics that much of the beauty of fireworks is woven.

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[41] Charles Mauron, Aesthetics and Psychology (London: Hogarth Press, 1935), p. 36.

[42] Irving Deacon, To the Ballet (New York: Dodge Publishing Company, 1935), p. 25.

[43] Jan Struthers, Mrs. Miniver (New York: Harcourt Brace and Company, 1940), p. 21.

[44] Faber, op. cit., p. 180.

One writer says that an experience is aesthetic when it is eagerly awaited, prolonged, and looked back upon for its intrinsic value.[46] Fireworks provide all of this, for there is expectation, partial fulfillment, teasing delay, exaggeration, and surprising gratification in a good pyrotechnical exhibit. All these excitements stir up attitudes and meanings founded in previous experiences, which, upon being aroused, become conscious thoughts and emotions.

> Somehow, growing up doesn't cure us of our delight in fireworks. Perhaps it is because they appeal by their beauty; perhaps because they satisfy a sheer, elemental love of noise and display, and grip us by that fascination which fire has for us in common with the beasts of the jungle. . . .[47]

V. FURTHER EVIDENCES OF AESTHETIC VALUES

It has been said that from the aesthetic standpoint, formal, use, and associational values are the stimuli releasing emotions. Emotional responses usually result in some overt activity. The activity may be immediate like gasping, shouting, pointing, or praying. It may be a delayed action, such as a recording or communication of the emotional experience in the form of music, painting, poetry, or some simpler literary effort. The immediate action is usually involuntary and physical, while the latter is purposeful and basically mental.

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[45] Van Meter Ames, _Introduction to Beauty_ (New York: Harper and Brothers, 1931), p. 4.

[46] _Ibid._, p. 11.

[47] Hartley, _op. cit._, p. 4.

Responsive activities resulting from stimulation by pyrotechnics. Mrs. Miniver knew that she was subject to an immediate physical response when she watched a fireworks display, for

> . . . When the first rocket went up Mrs. Miniver felt the customary pricking in her throat and knew that once again the enchantment was going to work . . . fireworks had for her a direct and magical appeal.[48]

Brock, as manufacturer and exhibitor of fireworks asks:

> Can any who have heard the long drawn Ah-h! of rapture from many thousand throats, at the burst of a flare of shells . . . maintain that the most dramatic moment on the stage is more affecting to the spectators?[49]

Everybody's records the same type of reaction in the following passage.

There is no question about the lure of fireworks.

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[48] Struthers, op. cit., pp. 22-23.

[49] Brock, op. cit., Preface xiii.

> No spectacular thing in the world is so satisfying, nothing has a more nearly universal response than a fine pyrotechnical display.
>
> Maybe you remember, from your childhood, the awful struggle of choice between firecrackers and rockets, chasers and pinwheels; maybe you recall your bitter suffering when the firecrackers were exhausted--a suffering tempered by your anticipated delight in the rockets.
>
> At last you touched the match to the fuse. The hiss as the rocket started into the twilight, leaving a train of blood red sparks, was music to your ears. Then came the joy of the boom as it exploded in mid-air, and the long-drawn "ah-h-h!" of pure satisfied delight as a myriad of colored stars glorified the heavens.[50]

Some of the earlier written records have preserved, to a meagre extent, the feelings of the people while viewing the shows.

> Many Pots of Fire being fired together, do make a fine representation and recreation to the Spectators and cause a wonderful shout amongst the common people which are standers by; for those pots being filled with Balls of Fire and Flying Serpants for the Air, they will so intermingle one within another in flying here and there a little above the ground and giving such a volley of reports that the air will rebound with their noise, and the whole place be filled with sundry streams of pleasant fire.[51]

Music resulting from inspiration by fireworks seems not to be very extensive. The most familiar example is the "bombs bursting in air" from the Star Spangled Banner.

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[50] Hartley, op. cit., pp. 3-4.

[51] Jean Lewiechon, Mathematical Re-creation (n.n., n.p., 1674), p. 273.

Handel's Fireworks Music was written to go with the performance of fireworks given in London on the occasion of the Peace of Aix-la-Chapelle.[52] The work consists of an overture and five short movements intended to illustrate some of the set pieces. It was scored for fifty-six wind instruments. The public rehearsal a week before the fireworks celebration drew a crowd of 12,000.[53]

The Fireworks Music was not his first musical association with pyrotechnics. Addison's Spectator, in reviewing Handel's first opera, Rinaldo, says:

> . . . in the meantime, to find out a more agreeable entertainment for the Winter-season, the Opera of Rinaldo is filled with Thunder and Lightning, Illuminations and Fireworks; which the audience may look upon without catching Cold, and indeed without much Danger of being burnt; for there are several Engines filled with Water, and ready to play at a minute's warning, in case any such accident should happen. . . .[54]

More recently Stravinsky found inspiration in fireworks and produced a short orchestral fantasy called Feu d'Artifice. He had intended the music as a present to Rimsky Korsakoff for the event of his daughter's wedding, but unfortunately Korsakoff died before the manuscript was delivered.[55] A newspaper criticism of the composition says:

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[52] Oscar Thomas, editor, "Fireworks Music," The International Cyclopedia of Music and Musicians (New York: Dodd Mead and Company, 1939), p. 548.

[53] R. A. Streatfield, Handel (New York: John Lane and Company, 1909), pp. 201-2.

[54] Howard D. McKinney and W. R. Anderson, Music in History (New York: American Book Company, 1940)

> In Fireworks can be discerned that budding instinct for realism that was destined to expand in futuristic directions. There are woodwind figures that revolve like pinwheels . . . others that ascend in long curves, like rockets, and explode in pizzicato chords with muted horns or trumpets. Finally the scintillating activity gathers force and explodes in one triumphant bomb. Here again the musical thought is light, but in descriptive illusion and in tonal cunning the piece is inspiring.[56]

Toward the end of the nineteenth century popular songs provided subjects for many successful fireworks set pieces. Much of the interest in these pieces was derived from the band accompaniment and the opportunity for vocal effort on the part of the crowd. The idea sprang up spontaneously when a small group started singing "Have You Seen the Shaw?" as he fired a portrait of himself from his box. Everyone joined in and thereafter specific set pieces were planned for singing purposes.[57]

Russel Bennet wrote music to accompany the fireworks shown in the Lagoon of Nations at the 1939 New York World's Fair. His compositions were consciously based on the visual effects of the fireworks.[58]

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[55] Igor Stravinsky, Stravinsky, an Autobiography (New York: Simon and Schuster, 1936),p. 36.

[56] Thomas, op. cit., p. 548.

[57] Brock, op. cit., pp. 52-53.

[58] "Symphonies in Sight and Sound," Magazine of Art, 32:290, May, 1939.

During the eighteenth and nineteenth century the number of prints portraying fireworks displays seems quite out of proportion to the total number of prints published. The imbalance indicates either the favor accorded fireworks displays by artists or the general popularity of such affairs.[59]

> Pyrotechny paints on the canvas of the sky; and the results are at once the joy and despair of the artist. Many artists have tried to record their impressions, but the results have been generally disappointing. Whistler came near success, but even his wonderful work conveys merely the dying embers of passed glory. One feels that here has been a magnifiscent display but the scene in its full grandeur has not been depicted.[60]

A possible reason why the artists persisted in trying to record their impressions even though they were not successful is offered by Hodgkin. He feels that

> . . . the evanescent character of the entertainment, prepared with so much care, cost, and forethought, itself suggests that these should not have been wholly lost when the fete is over, but that the spectacles themselves should be able in a measure to nenew, and posterity to share the delights of the fleeting hours in which had perished so much of the labour and skill of the architect and the artificer.[61]

Producer and consumer restrictions on the art element. Commercial exploitation of fireworks has not been entirely a help to the increasing of art quality in pyrotechny. The fault seems to lie as much with the consumer as with the producer.

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[59] Brock, op. cit., p. 23.

[60] Ibid., Preface xiii.

[61] Hodgkin, op. cit., "Halinitropyrobolia," II and III.

In 1930 some municipalities were airing their dissatisfaction with the blind buying they had to do. They felt that they could tell nothing about the fireworks they ordered until they had been fired and after the artifices were in the air the purchasers could only tell whether the effects had been pleasing or displeasing to the eye. This knowledge was not sufficient for the municipal governments to determine whether or not they had gotten full value for the money spent.[62] Reading the build-ups given pyrotechnic pieces in sales catalogues quickly exposes the justification of the complaints. Following is a description of a Comical Aerial Novelty and a Pyrotechnical Mardi Gras.

> Swarms of fireflies and lightning bugs. Novel and interesting is this number. Dashing through the air are brilliant flashes creating explosions. Mammoth saucisson bomb shells used. The crazy action of the bug-like effect creates roars of laughter.
>
> A riot of color and flying globes of fire! Hundreds of spectacular projectors arranged in group formation so as to form entrancing designs when in action! Myriads of varied colored stars--a profusion of feathery golden glow, accompanied by a rattelty-bang finish, makes this number a tremendous hit.[63]

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[62] Joseph W. Nichalson, "Municipal Money's Worth," The American City, 42:161, June, 1930.

[63] *Ibid.*, p. 161.

Even Mrs. Miniver found her small scale purchasing adversely influenced by the advertising propaganda.

> . . . when buying fireworks, [she] was apt to be led away by fantastic titles; she would order Humming Spiders, Witches Cauldrons, Mines with Serpents, Boquets of Gerbes, and Devils among the Tailors, largely in order to see what they were like. But Clem knew that with fireworks, as with cocktails, the sober, familiar names usually produced the most interesting results.[64]

The municipal government of Milwaukee tried to overcome the difficulties by putting out a specifications and bid sheet for the purchasing of Fourth of July displays. All the items desired were specifically described in detail. One piece was a five inch, one break, Shower of Pearls. This was to consist of two parachutes with a string of twenty bright aluminum stars between them which were to burn at least thirty seconds. Another was a six inch, one break, Wisteria, consisting of green and blue stars resembling blossoms. A third was a six inch, three break, Shell of Shells, to be arranged of twenty-four small shells, assorted eight in a break, to fire consecutively. A Niagra Falls set piece was to be made one hundred feet long by fifty feet high. The falls was to consist of forty tubes of falling sparks which would rebound two feet upon hitting the ground. The whole piece was to burn for two minutes, being red to start, changing to green, and finishing in a brilliant aliminum.[65]

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[64] Struthers, op. cit., pp. 22-23.

These facts and comments show that pyrotechny has changed a great deal since the eighteenth century when the pyrotechnist carried out his work personally and occupied a position very similar to that of the artist or sculptor.[66] First the producers tried to confuse the public. Then, to protect themselves, the buyers placed restrictions on the fireworks manufacturers which nearly eliminated any possibility of creative designing.

The writer did find a few instances where art qualities had an opportunity to flourish without restrictions. Naturally such freedom hinges on the existence of reliable business concerns. Mr. Van Dusen, of the California State Fair, says that they usually request the main set piece to be the emblem of the organization featuring the display and the rest of the exhibit is made of set pieces designed by the contractor.[67]

The Canadian National Exhibition has the reputation of offering the largest, most beautiful and diversified pyrotechnic spectacles on the continent. The organization which gets their contracts for fireworks has an entire staff of designers, the director of whom is an accomplished artist in fields other than fireworks.[68]

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[65] "City of Milwaukee Specifications for Fireworks, issued by Central Board of Purchasers, City Hall, Milwaukee, Wisconsin, 1930," 26 pp., mimiographed, legal size.

[66] Brock, op. cit., p. 124.

[67] Phillip Van Dusen, personal letter, infra, p. 147.

Mr. Cronkite of Los Angeles shows his clients sketches and color slides of the most interesting portions of his previous displays when a show is being ordered. He says that some sponsors are willing to plan on a display where quality and beauty are paramount regardless of quantity. The entire show then can be designed from the standpoint of entertainment value, particularly to suit the occasion. Other committees subordinate art quality because they are more desirous of quantity. He believes:

> It is possible that display fireworks could be made an expression of art under certain limited conditions, depending on the people who sponsor them and those responsible for the designing and operation.[69]

The problem of planning a pyrotechnic display was given to the architecture students at the Beaux Arts Institute of Design in New York. The design was to be created for the time when the pyrotechnic effects were at their height. In judging the compositions four aspects were considered. The first and most important one was the design and imaginative conception of the arrangement as a whole. The suitability of the design for execution by pyrotechnic effects was the second consideration. Correct scale was the next factor judged, and the last aspect rated was the appropriateness of the plan to the commemorative requirements established with the statement of the problem.[70]

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[68] Frederick Wilson, personal letter, infra, p. 145.

[69] C. E. Cronkite, personal letter, infra, p. 142.

The use of such a design problem in an art school is weighty evidence that display fireworks can fulfill the requirements of aesthetics when produced with the right guidance. Pyrotechny can be made an expression of art.

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[70] Robert S. Hutchins, "A Pyrotechnic Display," _The Bulletin of the Beaux Arts Institute of Design_, 12:3-4, February, 1937.

CHAPTER V

SUMMARY AND CONCLUSIONS

The problem taken under investigation by the writer was twofold: (1) to show the path of the evolution of pyrotechnics, and (2) to provide whatever proof exists that fireworks have had some art significance to mankind.

The phenomonon of combustion is obviously the point of departure in tracing the evolution of fireworks, and the developments which resulted from the existence of fire were numerous. Since the purpose in tracing the evolution of the medium was solely to provide background for conclusions concerning pyrotechnical contributions to art, the trend of evolution as suggested by historians in the field was accepted by the writer, and presented after condensing and assembling their several views.

Fire was at once serviceable and devastating. Prestige was accorded to those who could control fire to man's advantage. By capitalizing on this prestige, practices of magic were developed, the purpose of which were to coerce the forces of nature. Ceremonies so intended often inadvertently provided valuable information about the properties of matter. People began to see that nature would not bend to their will, and gradually increased knowledge about fire and combustion possessed by some of the sorcerers was turned to the coaxing of dieties with prayers and sacrifices. In this way fire and religion intermingled. In time, a few of the greater minds began to investigate new relationships of matter and alchemy developed. Fire was still the first hand assistant and sulphur and salts were closely allied to the whole field of experiments. Knowledge of the effects of combining such elements was inevitable and their manipulation resulted in the next steps in pyrotechny.

During the time that the principles of combustion were a mystery to the people at large, fireworks were used to inspire the populace, stimulate religious fervor, and encourage devotion. As the common people developed an understanding of the materials and their action, pyrotechny became dramatic entertainment with a tremendous popular appeal.

Probably the Chinese were the first to know fireworks, although possibly their information came to them from Egypt. Imperial Rome imported the knowledge of fireworks which later decayed with the state. By the time of the Crusades only Greek fire remained. However, Italy made the most of the information and became the scene of great pyrotechnical development.

The structure of artifices has changed but little over the centuries. The first devices, crackers and rockets, are much the same today as in the beginning. However, knowledge of variations of material within the structure has changed and improved, and the scenic beauty, of color especially, is far beyond that of earlier periods. Fireworks were once an accessory to elaborate architectural structures; today aerial fireworks can be relied upon for their effects alone. Technical development of quick match was largely responsible for this advance. Just as the art of fire once brought about the perfection of scientific knowledge, chemistry and science are at present assisting in the developments of the art of aerial fire.

To show that the impermanent fiery pictures produced in the night sky are of such a nature as to be called a work of art necessitates a statement about art in general.

Aesthetic reactions are, in the main, subjective emotional responses. Such responses result from stimulation by the qualities of use, associational, and formal values. Responses to the formal values are probably the most purely aesthetic, but influence of use and associational values are unremovable and inevitable, especially in such arts as architecture.

In showing the presence of these three stimuli in a pyrotechnical display the writer feels that the art significance of pyrotechny has been demonstrated.

Formal values are usually the modes of expression which present the use and associational values to the observer. Two aspects, temporal and spatial, make up the field of art expression, and pyrotechny is a peculiar fusion of the two. A good pyrotechnical display incorporates the principles of the space arts with symmetry, radiation, balance, and emphasis. As a temporal art fireworks also show the quality of rhythm. The total of these principles results in harmony, a fusion which produces pleasurable sensations of satisfaction.

The formal elements of design, in their simplest forms are line design, color, and pattern. The dynamic power of the upward moving line design of aerial fireworks is undeniable. The intensity of the luminous brilliance of pyrotechnic colors is one of their outstanding qualities. Patterns, whether linear, all-over, or unit motif can be found in every fireworks display and have been preserved in many prints and photographs of artifices in action.

The many use values of pyrotechny, rooted in the realms of magic and religion no longer exist. Today expression of joy resulting from pleasure stimulation is the remaining use value. The power of pyrotechny, like that of all other arts, results from the presentation of familiar forms for recognition or from the excitation of the imagination by abstraction, or both.

The linkage of associational values with daily life is often unconscious. The most universal associational value in a work of art is probably beauty. To find a thing beautiful is to experience aesthetic pleasure. The beauty in pyrotechnics cannot be touched or cherished except in the mind, and this very quality of transciency gives them an excellence not to be found in the more permanent expressions of beauty. A strong flow of associative ideas inevitably results from the stimulation of a pyrotechnic display, for a good show creates anticipation, teases the spectator with delay and partial fulfillment of anticipation, and in climax is surprisingly gratifying.

For one form of art to stimulate production in another art field is not uncommon. Drama inspires music; music inspires dance; and dance, poetry. Here again pyrotechny has done its share in inspiring the arts. Handel received a commission to compose music to fit a display of fireworks in the middle of the eighteenth century. Russel Bennet did the same thing in 1939. Stravinsky composed some fireworks music, solely because the subject fired his imagination. Hundreds of old prints, wood blocks, and etchings were made depicting fireworks shows, in spite of the fact that the glory of the display could never be adequately recorded. It seemed to be a challenge to the artists, especially of the seventeenth and eighteenth centuries. In the eighteenth century the pyrotechnician was considered more of an artist than he is today. This is not such an unusual condition, however, for the same is true of pottery makers, and industrial designers.

The lack of standing of pyrotechnicians is due in part to the fraudulent producers, who, with the advent of the industrial era, sprang up in this and numerous other fields. Hiding behind the old traditions of secrecy of the trade, they made it impossible for buyers to determine what they were getting for their money. As a result, stringent regulations in the form of specific bid sheets were used by groups desiring display materials. This fact made it difficult for the reliable companies to function as artists, for all elements of originality had been carefully prevented in the effort to insure getting material at least as good as the buyer had intended. At present a few producers have risen above the restrictions, and by meritorious performance have again earned for themselves the title of artist.

Briefly stated, the following criteria of art have been established:

1. Aesthetic response is the result of stimulation by formal, use, and associational values recognized in the object or activity.

2. Use and associational values are expressed by means of formal principles and elements of design.

    a. The formal principles are symmetry, radiation, balance, emphasis, and rhythm, resulting in harmony.

b. The formal elements of design are line, pattern, and color.

Pyrotechnics are therefore capable of stimulating aesthetic response because:

1. Although completely transcient in form they demonstrate each and all of the formal principles of art and formal elements of design.

2. They serve, admirably, the use value of entertainment, and pleasurable experience.

3. Both in imaginative abstractions and in realistic representations they stimulate an endless flow of associative ideas.

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APPENDIX

225 Maple Street
Salinas, Calif.
April 3, 1942

China Institute in America
119 W. 57th St.
New York City, New York

Gentlemen:

The Chinese Consulate in Los Angeles has suggested that I write to you in hope that you may have the information in which I am interested.

I am writing a thesis on the evolution and art significance of fireworks. I do not seem to be able to find much written about China's contribution, either historical or modern, except for passing comments in history books to the effect that fireworks developed in China long before the discovery of gunpowder in the Western world. The professor of Asiatic studies at the University of Southern California, Dr. Von Koerber, tells me that he knows of some things in Chinese, but these have not been translated. He feels that there may be some stray article of which he is not aware. Do you know of any material from which I could get descriptions of present day recreational fireworks or more complete information about their early development?

I am sending you a stamped airmail envelope in hope that you can help me. I must have my work finished by the middle of May.

Thank you,

(COPY)

CHINA INSTITUTE IN AMERICA
Incorporated
119 West 57th Street, New York, N. Y.

April 22, 1942.

Miss Leila Sturgis,
225 Maple Street,
Salinas, California.

Dear Miss Sturgis:

I am sorry that other pressing duties have prevented me from answering sooner your inquiry of April 3 regarding published materials on Chinese fireworks.

I find an interesting paragraph on this subject on page 241 of "Things Chinese" by J. Dyer Ball published in Shanghai, 1925. Since I am not sure if this book is accesible to you, I am taking the liberty to give you the quotation herewith:

'The Chinese are proficients in the pyrotechnic art, and the fireworks which were exhibited at the end of this entertainment were chefs d'oeuvre of all skill--the four elements having been called into requisition to furnish animals, birds, fishes, and reptiles, both real and imaginary; from whose bodies issued streams of flame. Five dragons ascended into the air, and were metamorphosed into fire-vomiting lions; a huge bird, of some unknown species, fluttered in the air in a sheet of flame, presently a huge serpent crawled from out of the beak of the bird, and was lost to view in many-tinted flames; one large lantern ascended, in a mass of fire, from which smaller lanterns issued, which in their turn sent forth various and innumerable forms. On the back of an enormous fish was seated a portly mandarin, from whose aldermanic corporation burst forth streams of fire, which appeared to cause intense delight, and excite the greatest merriment amongst the spectators. The last firework was by far the most beautiful and perfect, being completely artistic in its details; this represented a mandarin's house with the whole of the adjacent buildings belonging to the residence, the roofs being ornamented with bells and figures; this burned for some time, and then changed into a mandarin seated in his sedan-chair, with the usual train of attendants, bearing flags, beating gongs, and carrying lanterns; the effect of this mass of many-coloured flames, defining the outline of the various forms, baffles description; and as the last sparks died away, we could have been tempted to follow Oliver Twist's example and asked for more.'

I trust this will be of some help to you on your thesis.

Sincerely yours,

(signed) B. A. Liu

B. A. Liu, Research Associate.

BAL:km

225 Maple St.
Salinas, Calif.
April 13, 1942

Cronkite Fireworks Co.
126 W. Third Street
Los Angeles, Calif.

My dear Mr. Cronkite:

Mr. Otto K. Olson has suggested that you may be able to give me some information.

I am writing a thesis on the art significance of fireworks and have not been able to find out anything about the way shows are designed. I had an idea that somewhere there were people who planned the displays from the standpoint of beauty as well as fitting them into the time and money budget in the places where they were to be used. At Olson's, Mr. Fowler told me that you do just this, that you show your clients pictures of previous shows and sketches of things you have in mind. Could you tell me any more about this part of your work? Does the entire show have a plan for unity, repetition, color, etc., or are numerous unrelated units just massed together? What design elements do you consider foremost in your planning? Have you any sketches or photographs or other plans of previous exhibits which I could see when I am in Los Angeles around May first?

Still some further questions I would like to ask are these: Do you think that display fireworks have or could have enough of the fundamentals of art and beauty that they should be considered one form of art expression? Do you know any other sources of material from which I might get information similar to that which I have asked you or do you know any other designers to whom I might write? Speaking of things as they were before the war, in the past few years had there been an increase or decrease in the demand for fireworks and was the trend toward quantity or quality from the viewpoint of art?

I am enclosing a stamped envelope, hoping that you can help me. My work must be in by the early part of May.

Thank you,

C. E. CRONKITE
515 National Title Building
126 West Third Street
Los Angeles, Calif.

April 30, 1942.

Miss Leila Sturgis,
225 Maple St.,
Salinas, California.

Dear Miss Sturgis:

I regret that it has not been possible to reply to your letter any earlier, but I was called in on an Army Ordnance program that has taken up all my time.

Without going into too much detail I will endeavor to answer each of your questions more or less categorically in sequence.

To the first, yes, we do try to show clients results of former displays, together with sketches. For my part I try to take color slides of the most interesting portions of a large display and then show them wherever possible.

Secondly, we do try to follow a plan or theme whenever the day and time lends itself to it, but try to avoid repitition in both color and effect.

Thirdly, we do not necessarily consider any particular design element foremost. Anything will lend itself to a program, and color is not necessarily taken into consideration, except in the reproduction of a flag, flowers, fruit or similar object. The limited number of colors possible, require that some objects be reproduced in colors entirely foreign to them in nature.

Yes, I have sketches and other related material I will be glad to show you when here.

It is possible that display fireworks could be made an expression of art under certain limited conditions, depending on the people who sponsor them and those responsible for the designing and operation.

As fireworks men are pretty well dispersed because of war conditions and the ban on them, I do not now know of anyone to whom you might write.

Answering your last question is not so easy. Some Committees or Sponsors were more desirous of quantity rather than quality, consequently subordinating Art or quality, while others were quite willing to plan on a display where quality and beauty were paramount regardless of quantity. In the latter case it was then a matter of designing the entire show from the standpoint of entertainment value to particularly suit the occasion.

For your information concerning the limits which are imposed on us in the matter of faithful design, here are the only actual colors that it is possible to make.

White.

Yellow, with some variations from light to orange.

Green, also with some variation.

Blue, light and dark, also purple and possibly heliotrope, altho the variations might not be very noticeable.

Red, from brilliant to a sort of pink.

It will be understandable that it would not be practical to try to use many variations of a single color in any one piece as the contrast would not be noticeable. But in the Flag a decided red and blue would be used, while in some other piece lighter or darker shades might be used to suit the particular design.

Yours truly,

(signed) C. E. Cronkite.

225 Maple Street
Salinas, California
April 3, 1942

Canadian National Exposition
Elwood Hughes, Manager
Toronto, Canada

Dear Mr. Hughes:

Mr. William H. Fowler, the purchasing agent for the Los Angeles Chamber of Commerce, suggested that you might be able to help me find some of the information for which I am looking.

I am writing a thesis on the evolution and art significance of fireworks. He tells me that as far as our country fairs and Fourth of July celebrations are concerned the three elements price, space, and time are the only requirements given the jobbers who provide their shows. Do you ever use designers outside of the fireworks plants to design displays around the theme of the exposition? Do they make at the plant any special artifices to fit the occasion? If so, who are the designers? Would you say that there is real consideration given these displays to make them more beautiful each year as well as more spectacular? To what extent do you feel that art principles determine the material selected for the pyrotechnic shows in the expositions?

Perhaps you are not the one to whom all these questions should be put, but I would certainly appreciate any help you or your associates could give me. I am enclosing an airmail stamped envelope since my work must be completed by the middle of May.

Thank you,

(COPY)

CANADIAN NATIONAL
EXHIBITION

Head Office, 7th Floor, Lumsden Building, Toronto 2, Canada

April 13th, 1942

Miss Leila Sturgis,
225 Maple St.,
Salinas, Cal.

Dear Madam:

This to acknowledge your recent letter in which you ask for information concerning the display of pyrotechnics at the Canadian National Exhibition.

We do not use designers outside of the fireworks plants to design displays attuned to the current theme. That is because the organization which gets the contract for our fireworks has a staff of designers capable of providing anything we may require.

For many years this exposition has enjoyed the reputation of having the largest, most beautiful and diversified pyrotechnic spectacle on the continent. It is difficult to answer your question as to the extent to which art principles determine the material selected but we know that the director of that department of the Hand Fireworks Co. is an accomplished artist in other than fireworks.

We trust this is the information you require but we will be glad to answer any further questions concerning our display.

Yours truly,
CANADIAN NATIONAL EXHIBITION ASSOCIATION

(signed) Frederick Wilson

Advertising - Publicity

FWilson:dh

225 Maple Street
Salinas, Calif.
April 15, 1942

Mr. Phillip Van Dusen,
California State Fair,
Sacramento, California

My dear Mr. Van Dusen,

I am writing a thesis on the possible art significance of fireworks, and in searching for material Mr. Otto K. Olson reminded me that you have excellent fireworks shows at the State Fair in Sacramento. However, I have not seen any of these. Could you answer the following questions for me?

Do you have a "fair theme" which is carried out in the fireworks or do you have specifications for various pieces which you give to the company who gets the contract, or is the entire exhibit left up to them? As far as the art qualities within your displays is concerned who plans the layouts and the contents?

I would appreciate any help you could give me and my work must be finished early in May. I am including a return stamped envelope.

Thank you,

(COPY)

CALIFORNIA STATE FAIR
Eighty-seventh annual classic
Sacramento - August 29th thru September 7th, 1941

April
Seventeenth
1942

Miss Leila Sturgis
225 Maple Street
Salinas, California

My dear Miss Sturgis:

I am very much afraid that I will not be able to be of much assistance to you on your thesis on fire works displays.

Here at the State Fair, we divide the week up into special days and ordinarily there is one outstanding organization whose activities headline the day.

Wherever possible, we use the emblem of this organization as the feature set piece in the fireworks display. The rest of the fire works display is usually made up of the set pieces designed by the contractor.

Very truly yours,

(signed) Van Dusen

Philip A. Van Dusen

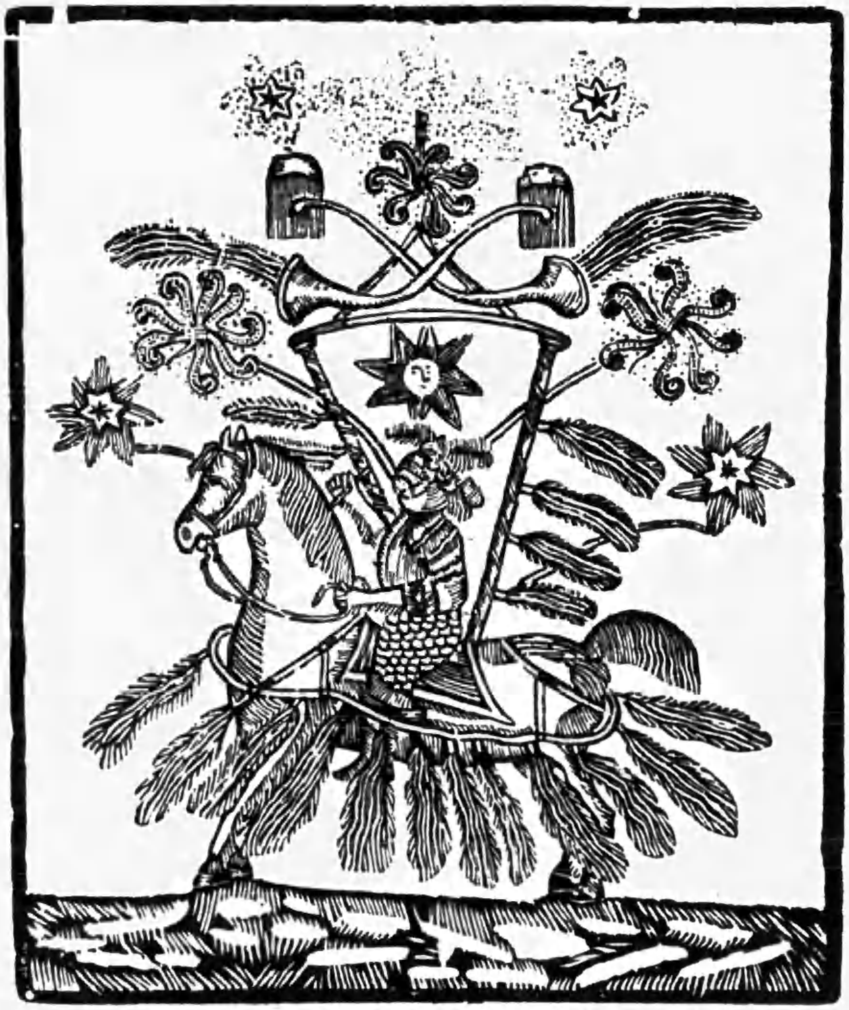
PAVD:AF

PLATES

PLATE I

Hodgkin, John Eliot, Rariora. London: Sampson Low, Marston and Company, Ltd., 1902. Vol. III, "Halinitropyrobolia," page viii.*

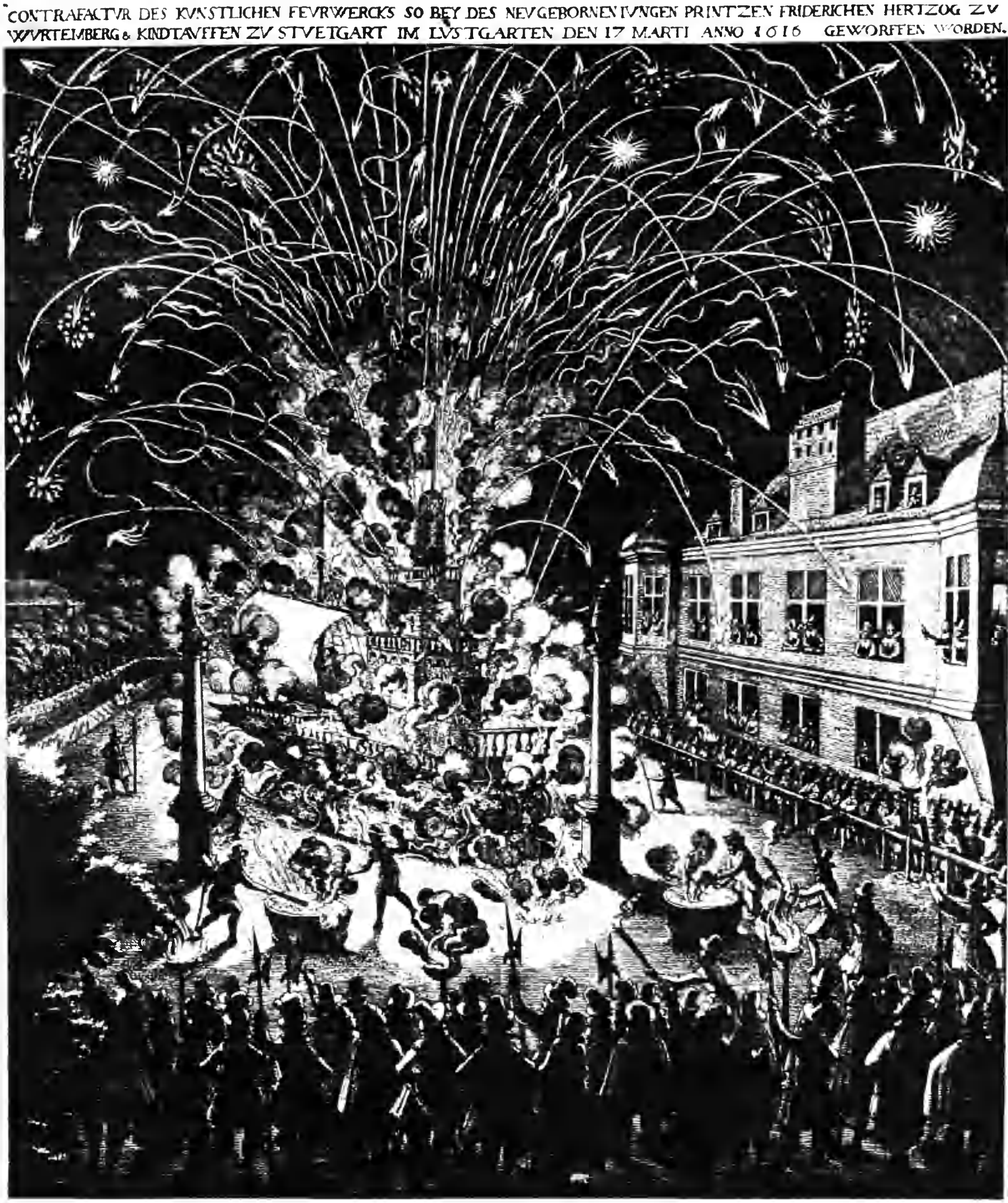
*Rariora is composed of three volumes and in Volume III there are two books, separately paginated. "Halinitropyrobolia" is numbered in Roman numerals, whereas "Books on Fireworks" and "Fireworks Displays" are numbered in Arabic numerals. All are parts of this second section in Volume III which has no specific title.



AN ANCIENT PYROTECHNIC DEVICE.

PLATE II

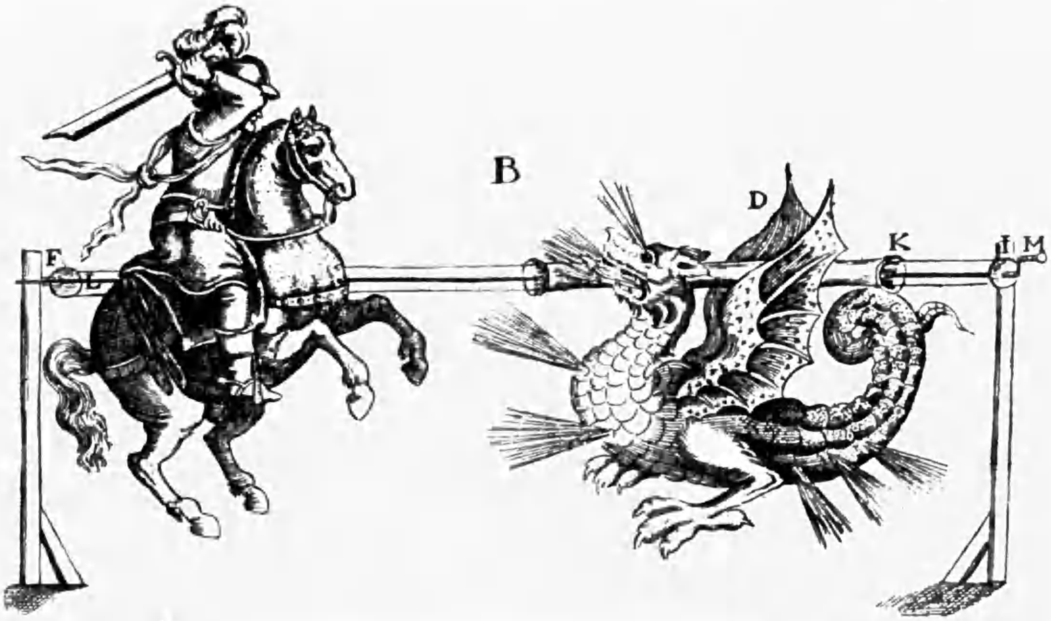
Hodgkin, John Eliot, *Rariora*. London: Sampson, Low, Marston and Company, Ltd., 1902. Vol. III, "Fireworks Displays," page 48.


CONTRAFACTVR DES KVNSTLICHEN FEVRWERCKS SO BEY DES NEVGEBORNEN IVNGEN PRINTZEN FRIDERICHEN HERTZOG ZV
WVRTEMBERG & KINDTAVFFEN ZV STVETGART IM LVSTGARTEN DEN 17 MARTI ANNO 1616 GEWORFFEN WORDEN.

FACSIMILE (REDUCED) OF THE PRINT OF FIREWORK DISPLAY, A.D. 1616, DESCRIBED ON PAGE 47. (NO. 9).

PLATE III

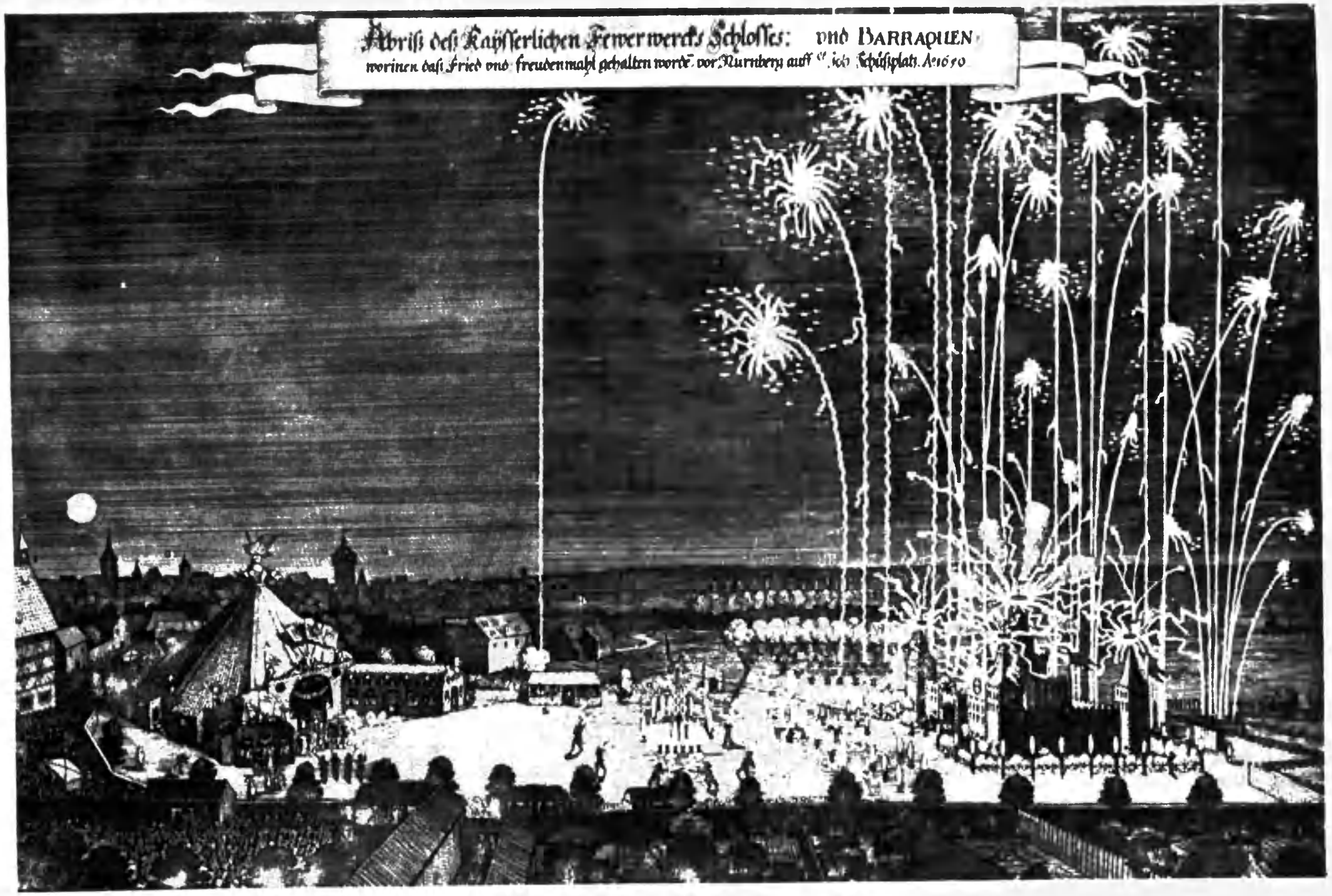
Hodgkin, John Eliot, *Rariora*. London: Sampson, Low, Marston and Company, Ltd., 1902. Vol. III, "Books on Fireworks," page 27.



ST. GEORGE AND THE DRAGON. (*BABINGTON*, 1635.)
The motions of the two figures are controlled by a cord and pulley, M.

PLATE IV

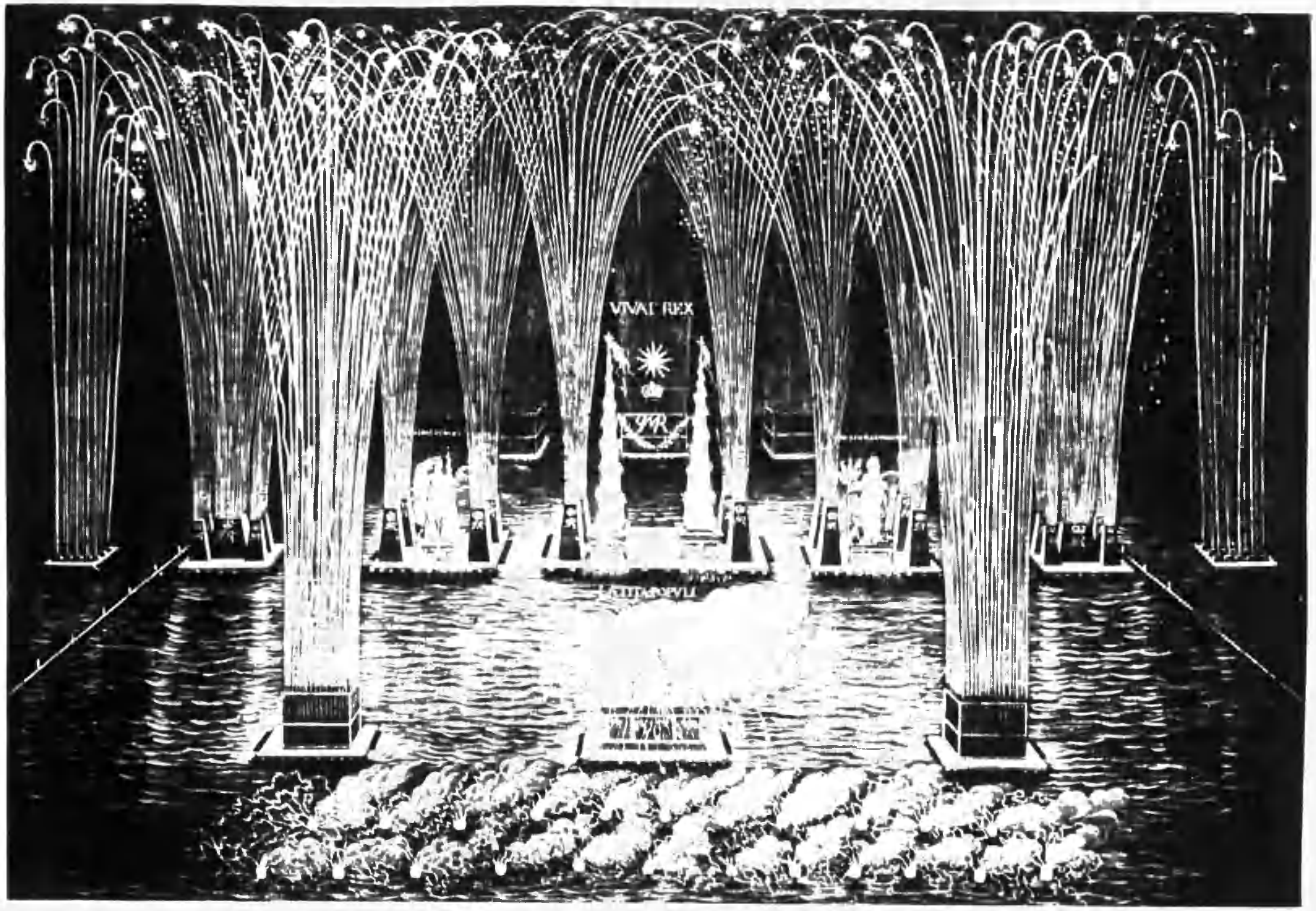
Brock, A. St. H., *Pyrotechnics: The History and Art of Firework Making*. London: Daniel O'Connor, 1922, page 22.


Abriß deß Kayſſerlichen Fewerwercks Schloſſes: vnd BARRAQUEN
worinen daß Fried vnd freudenmahl gehalten worde. vor Nurnberg auff St. Job Schiesplatz. Ao 1650

Firework Display at Nuremberg, 1650. From a contemporary engraving

PLATE V

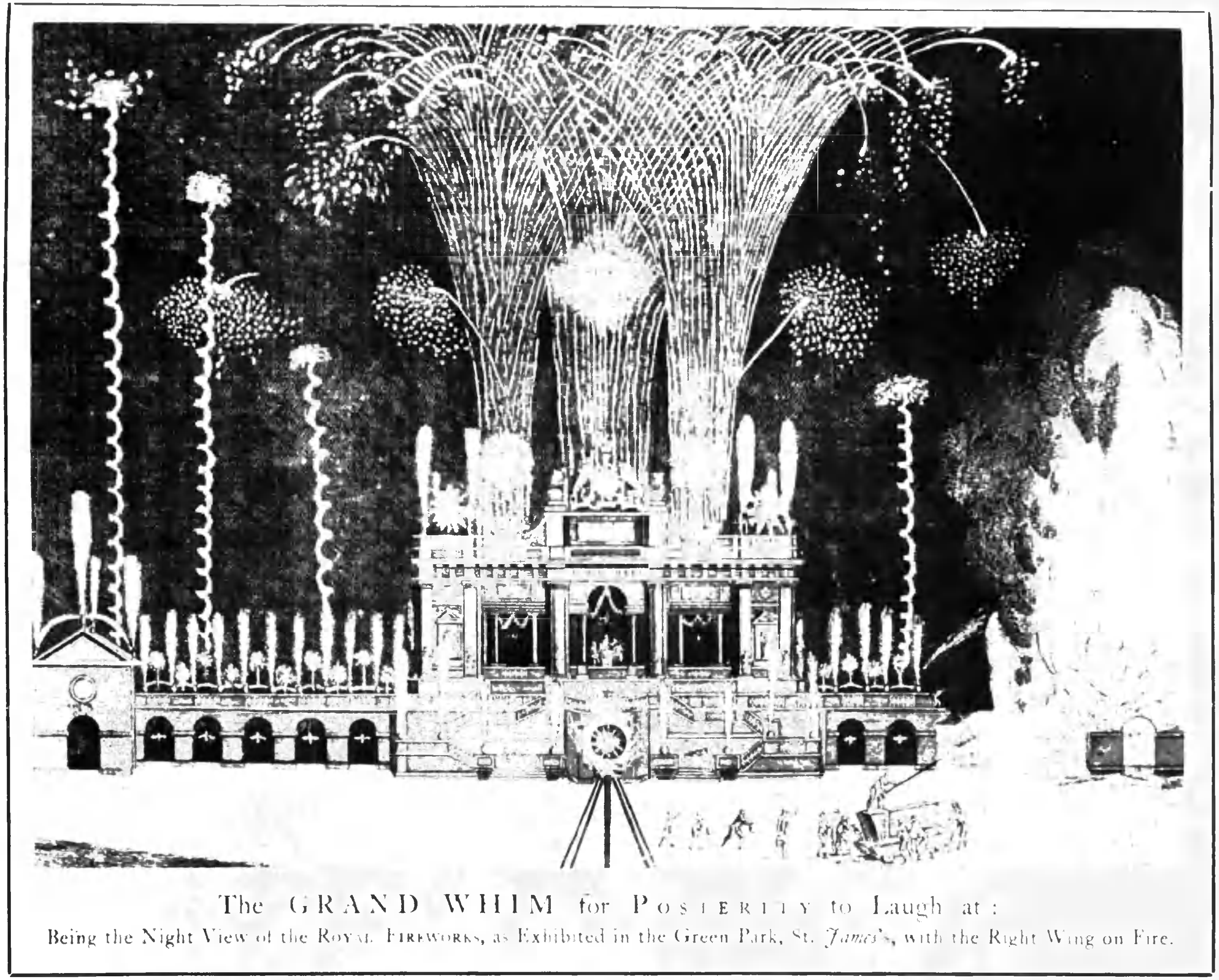
Brock, A. St. H., *Pyrotechnics: The History and Art of Firework Making*. London: Daniel O'Connor, 1922, page 28.



Fireworks on the Thames, June 17th, 1688. To celebrate the birth of a son to King James II, known to fame first as the Prince of Wales, and afterwards as the Old Pretender.

PLATE VI

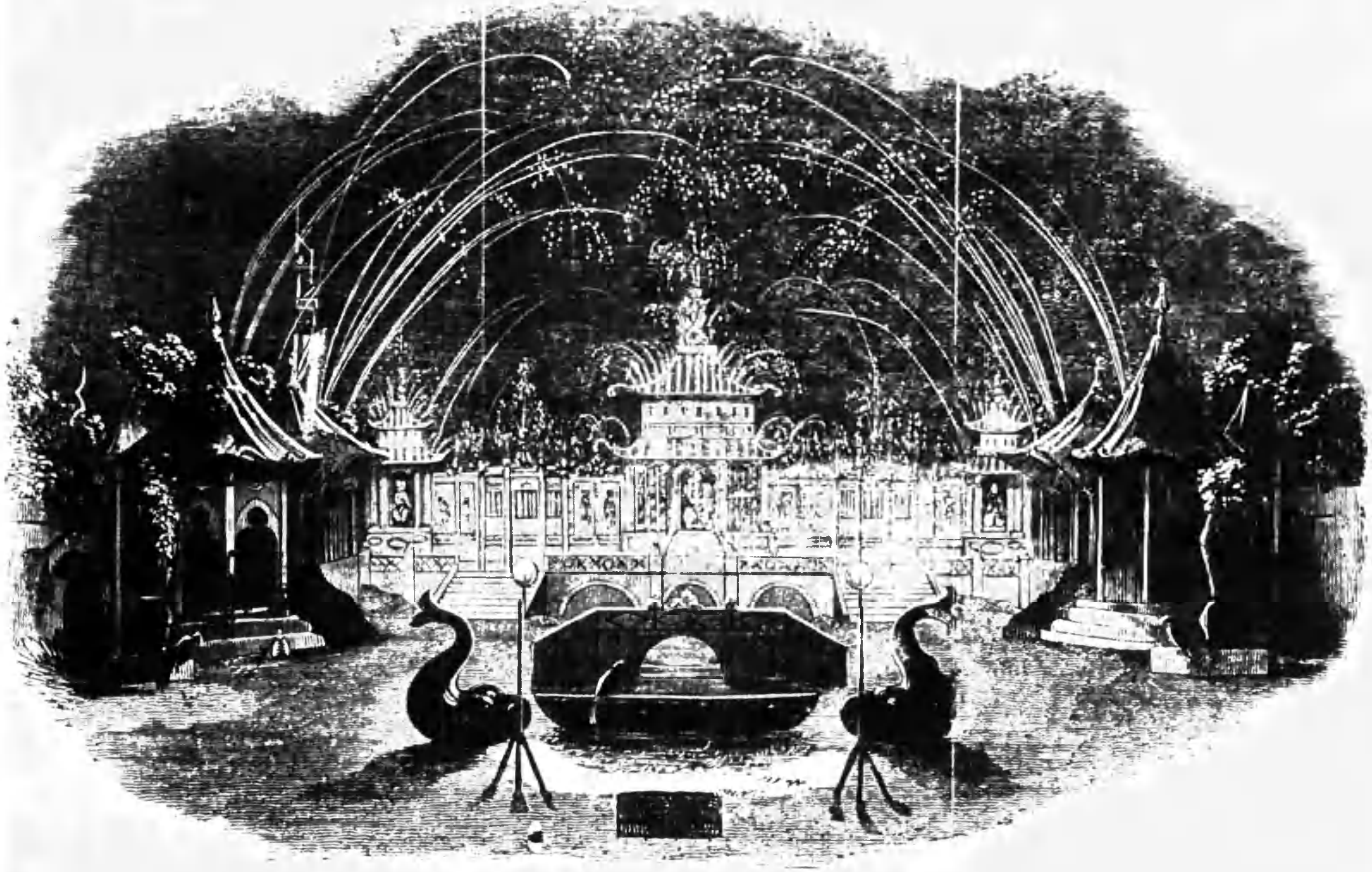
Brock, A. St. H., *Pyrotechnics: The History and Art of Firework Making*.
London: Daniel O'Connor, 1922, page 46.


The GRAND WHIM for POSTERITY to Laugh at:
Being the Night View of the ROYAL FIREWORKS, as Exhibited in the Green Park, St. *James's*, with the Right Wing on Fire.

Firework Display in the Green Park to celebrate the Peace of Aix-la-Chapelle, 1749.

PLATE VII

Brock, A. St. H., *Pyrotechnics: The History and Art of Firework Making*. London: Daniel O'Connor, 1922, page 36.

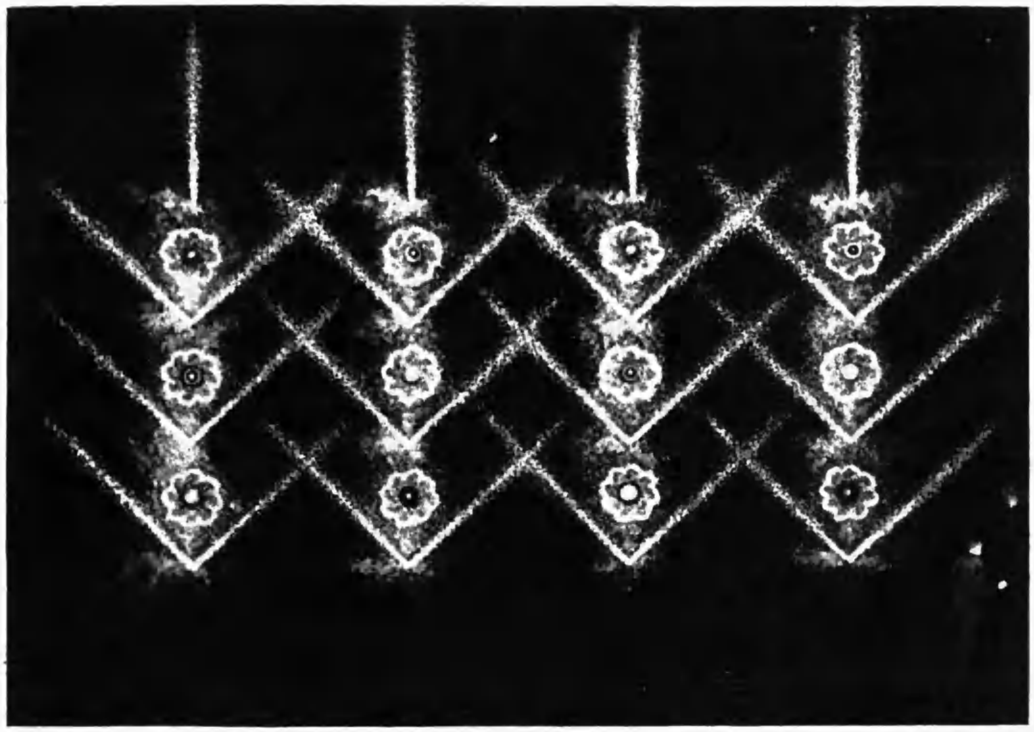


Firework Temple at Vauxhall, 1845. From a woodcut in "The Illustrated London News."

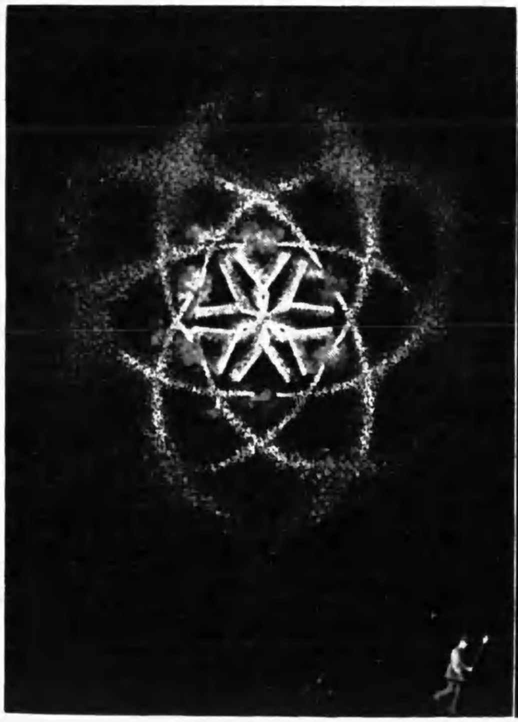
PLATE VIII

Brock, A. St. H., *Pyrotechnics: The History and Art of Firework Making*. London: Daniel O'Connor, 1922, page 128.

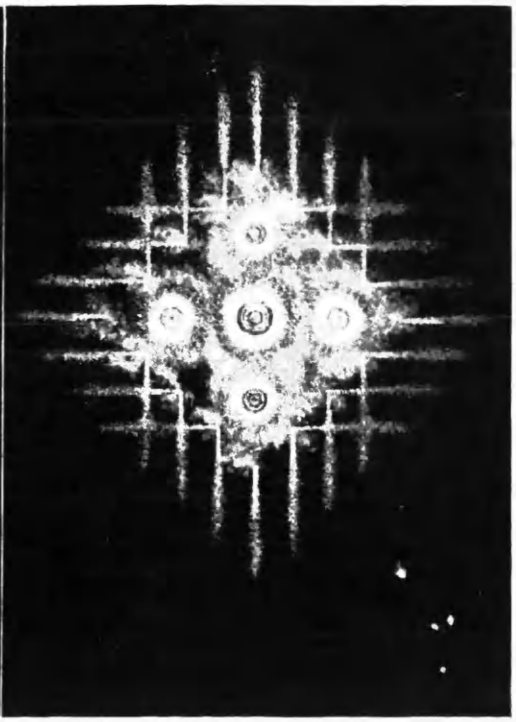
TYPES OF COMPOUND FIREWORKS



Lattice Poles.



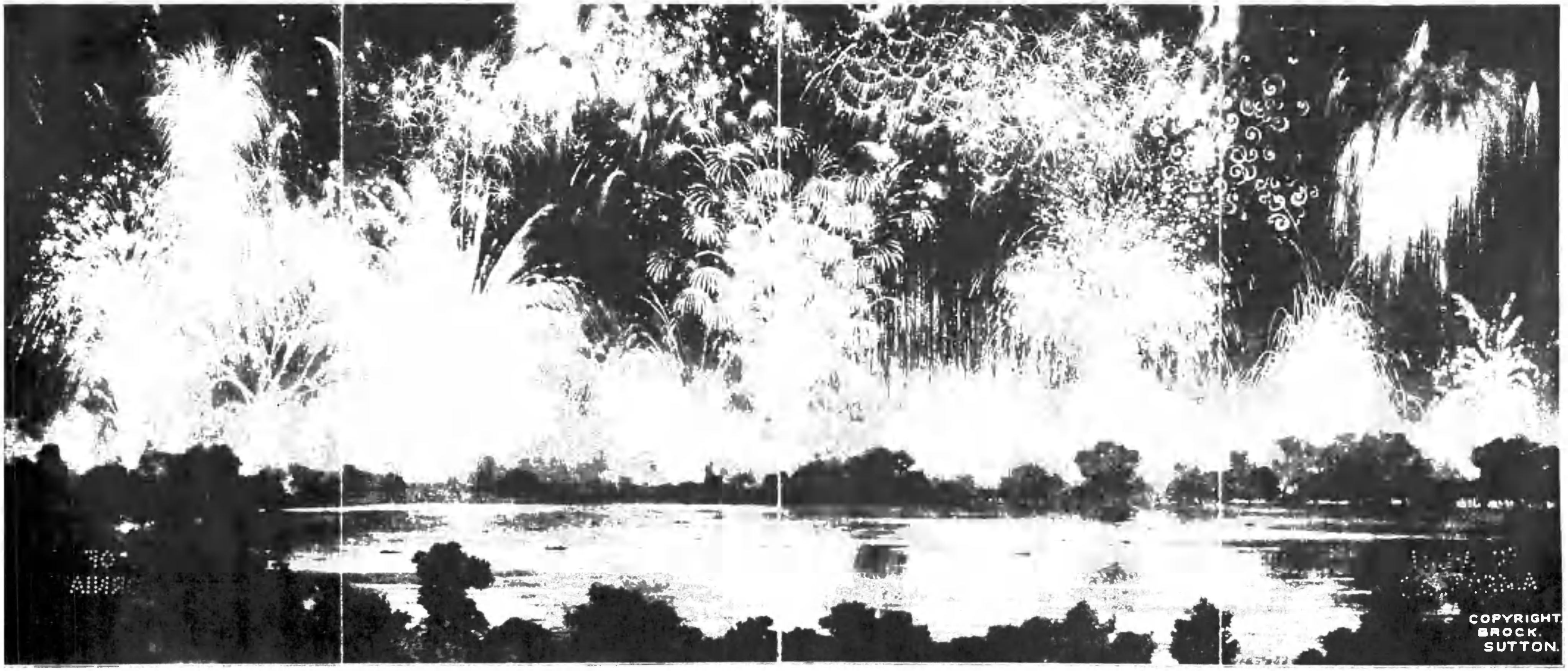
Chromatrope
(The outer fire forms the Guilloché of Ruggieri.)



Lattice Diamond
(The Feux Croisés of Ruggieri.)

PLATE IX

Brock, A. St. H., *Pyrotechnics: The History and Art of Firework Making*.
London: Daniel O'Connor, 1922, page 56.



PANORAMA OF SOME OF THE AERIAL EFFECTS IN THE NATIONAL FIREWORK DISPLAY AT HYDE PARK. 19th JULY, 1919